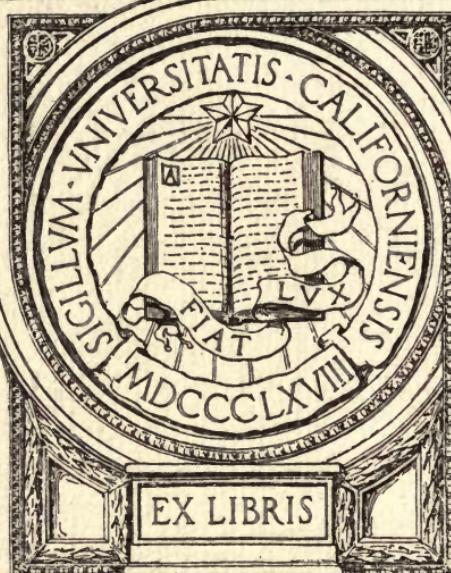
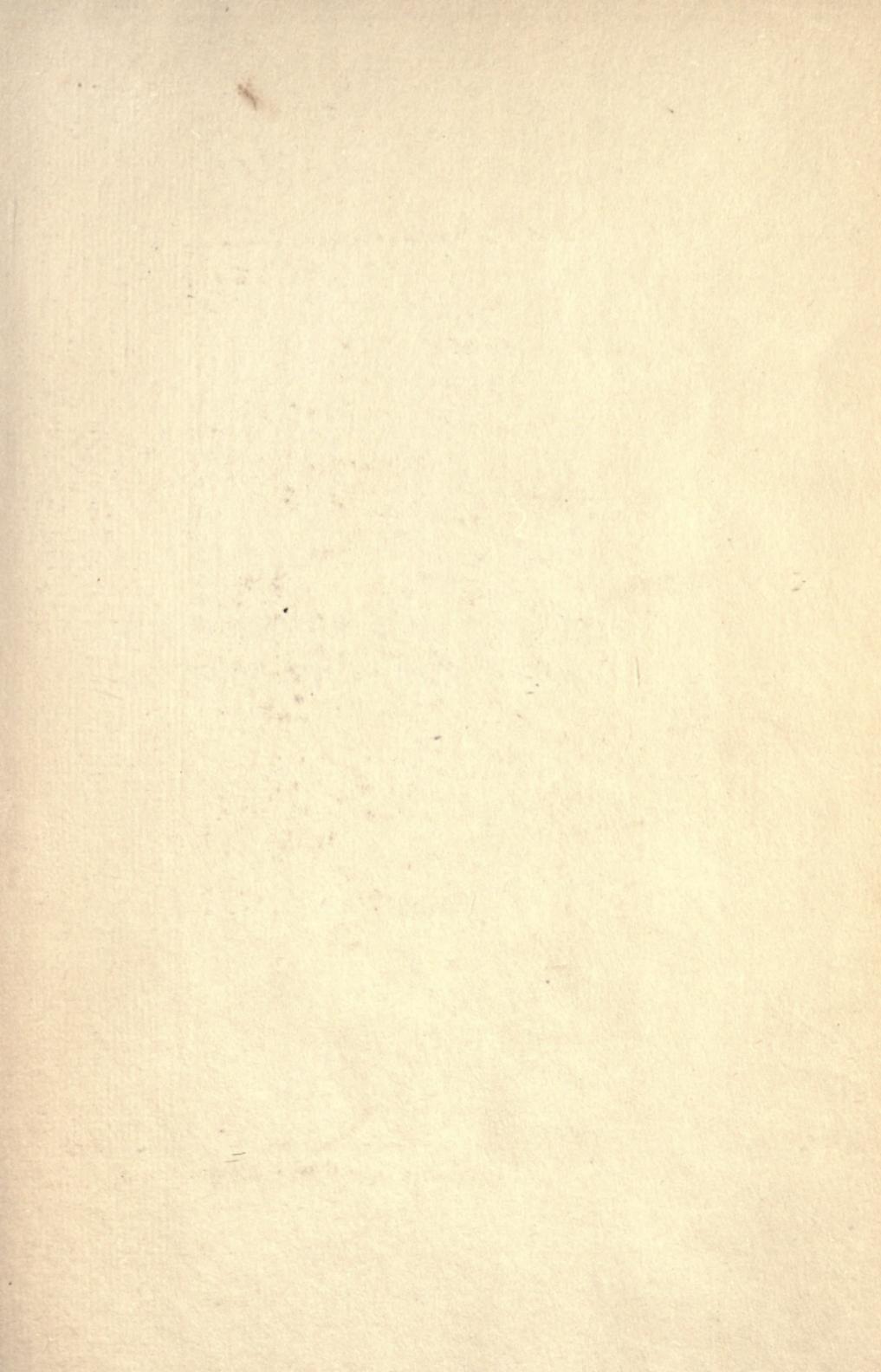
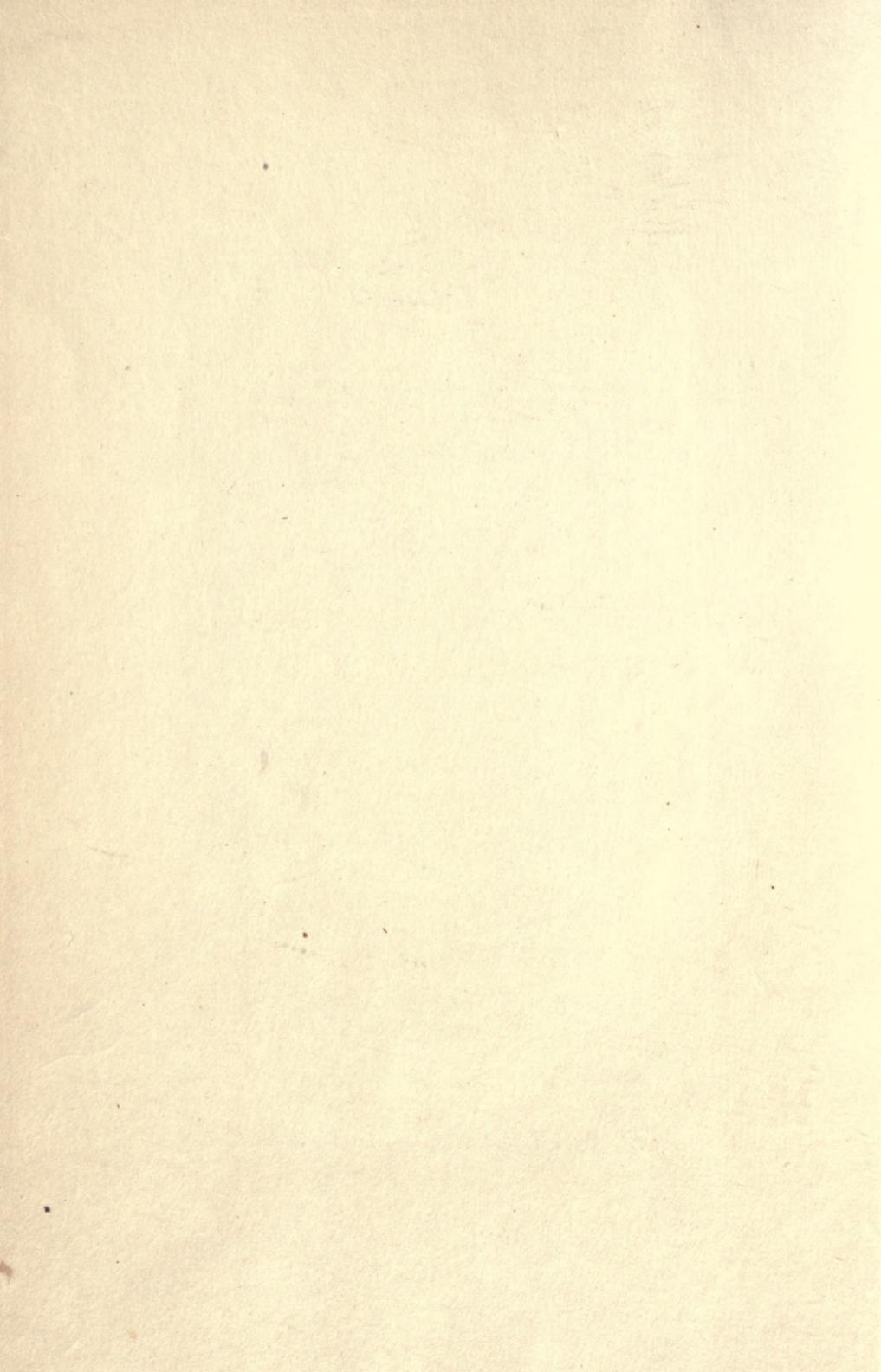


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**OUR FRIENDS AND OUR FOES
OF THE INVISIBLE WORLD**

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OUR FRIENDS AND OUR FOES OF THE INVISIBLE WORLD

HOW TO WOO THE FRIENDS
HOW TO CONQUER THE FOES

BY

HARVEY HERSEY, A.B., A.M.
"

*WITH ONE HUNDRED AND SIXTEEN
ILLUSTRATIONS*



UNIVERSITY OF
CALIFORNIA.

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THE NEALE PUBLISHING COMPANY

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PREFACE

This work is an attempt to reveal to the reader those living beings of the Invisible World which most concern us. The author is not aware that any other work, similar in plan and scope, has been published. Fragmentary parts of the general subject have been treated, but even these have usually appeared in so technical terms as to be of little, if any, avail to the general public. The aim here has been to cover the entire field, and in so plain and simple language that whoever reads may understand.

With this aim in view, Microbes In General are first considered, their nature, functions, origin.

Invisible Friends come next, their characteristics, where they live, what they do for us, how they do it.

This prepares the way the better to understand Our Invisible Foes, the chief purpose of this book. Forty-four different germs are treated as the active causes of forty-four different diseases. A brief chapter is devoted to each germ; showing what the germ is, how it enters the body, how it causes the disease, how, if possible, the disease may be cured, and, better still, how to prevent the disease.

Protection Against Our Invisible Foes is next in order, and has its full share of attention.

PREFACE

The work concludes with Victory — Its Reward — the great hope of final conquest and its infinite value to mankind.

So-called doctors' books are usually, if not always, written by doctors, exclusively in the interests of their profession. This book is written by a layman, exclusively in the interests of laymen.

Evidently the need for some such work, at the present time, is wide-spread and strikes deep. The fact that one-seventh of the human race die of a single disease caused by a single invisible foe, is wonderful. The fact that this disease is yet, with the right intelligence, easily preventable,— as well as all other contagious and infectious diseases,— is, if possible, still more wonderful. It shows how deep the want of the right intelligence among the people generally.

That this book may do something to turn on the searchlight is the hope of

THE AUTHOR.

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BOOK FIRST
MICROBES IN GENERAL

PART I WHAT THEY ARE

CHAPTER I THEIR NAME

AT a meeting of the French Academy of Sciences, held March 11, 1878, one of the principal points for discussion was whether the then newly discovered germs producing disease were plants or animals. The assembly was about evenly divided. One portion contended that the germs were all plants and should be called microphylaria, a word meaning small plants; the other that they were all animals, and should be called microzoaria, a word meaning small animals. The discussion was lengthy and waxed warm. Finally, Sedilot, an eminent French surgeon, arose in the assembly, and proposed a new name for these germs. He would call them microbes. His word had never before been spoken. The surgeon coined it then and there expressly to meet this occasion. The term means, he explained, a small living being, whether that being is plant or animal. If, on further study and investigation, the germs in question should be found to be plants, they would be properly named by calling them mi-

crobes. If, on the other hand, they should be found to be animals, they might just as properly be called microbes. Or, if scientists should finally discover, as a settled fact, that some of these invisible beings, whether friends or foes, are plants, and others are animals, the term *microbe* would still apply to them all with propriety.

The new word took with the French assembly, and acted as the olive branch of peace to their contention. Both parties seemed willing to give up, each its party name, and in its place to accept the new term with its broader meaning.

Since that time this new word has gone over the world, appears in all the dictionaries since published or revised, and is now used everywhere in common conversation.

It is true that the word *bacteria* is generally used to denote not only the pathogenic or disease-producing germs, but also almost an infinite multitude of similar germs inhabiting the air, the water, the soil, and which may be friendly or otherwise to man. But this word directly signifies plants, and plants only. To apply this word to animal germs would be improper.

Yet it is well known that a number of the disease-producing germs are animals. The germ that is the active cause of malarial fever is an animal. The germ that causes the yellow fever is an animal. The sleeping sickness of Africa, which is so terribly destructive, is caused by an animal germ. The germs which produce the dysentery and syphilis

are animals. The Texan Fever which destroys so many cattle is also caused by an animal germ.

How many more disease-producing germs, both as regards man and the lower animals, may be found to be animal, we know not. Nor do we know how many of that countless number of these invisible beings which do not produce disease, may yet be found to be animals.

Therefore, under all the circumstances, it is preferred in this work to call all these beings of the invisible world, microbes,—whether or not they be the cause of disease, whether they be our friends or our foes.

CHAPTER II

THEIR SPECIFIC NATURE

IT is easy to identify all microbes as something different from all other living beings. They are all one-celled. Each one consists of the merest speck of protoplasm,—a jelly like substance, enclosed in a minute sac. All other living beings consist of many cells. The microbe alone is a single cell. This speck of protoplasm is the first form of life on the earth, and is as much a living thing as any other living being.

With comparatively few exceptions, all these unicellular beings are transparent. If large enough you could see through them as through glass. In water they look like the water. In air they look like the air.

But in a few cases microbes are known to be colored. Cast-off boots and shoes, laid in a damp place, sometimes accumulate a greenish mold. A microbe produces that mold and is of the same color. The mold on bread is the work of the microbe. When the mold is whitish or gray, the microbe that produces it is of that color. When the mold is reddish, the microbe is reddish.

Instances have been known where the bread administered in the Lord's Supper has been tinged

with a reddish mold, and the priest administering the sacrament, under such circumstances, has held the bread up before the communicants, declaring that they could see for themselves that the emblems have verily been turned into the real flesh and blood of the crucified Lord! The microbe that was responsible must have laughed in his sleeve and felt highly honored!

Then, again, a rain in winter has been known to color the snow red. The people in such locality have wondered why it rained blood, and feared that it portended some awful judgment upon them. The truth was, some neighboring water contained reddish microbes in abundance. The water evaporated, was taken up into the clouds and the microbes with it. When it condensed and fell again as rain, the microbes came down with it and colored the snow. How a little knowledge banishes fear! As light comes, ghosts go.

CHAPTER III

THEIR SIZE

OF all living beings microbes are the smallest. They, of course, like all other plants and animals, vary in size. But to see them the eye must be aided by a microscope magnifying from one thousand to fifteen hundred diameters. This means that in order to see them they must be magnified so as to appear from one to two and a quarter millions as large as they really are.

But small as these beings are, they are yet subject to definite measurement. Plenty of them are so small that they measure only three-tenths of a micromillimeter in diameter.

Now a millimeter is the $\frac{1}{25}$ inch. A sphere one millimeter in diameter would be the size of only a tiny drop of water. We may see how many microbes of the smaller size may be packed within the space occupied by that tiny drop.

The micromillimeter being a thousand times smaller than the millimeter, means $\frac{1}{25000}$ inch. Therefore the spherical microbe one millimeter in diameter is the same as a sphere $\frac{1}{25000}$ inch in diameter. And the spherical microbe $\frac{3}{10}$ of a micromillimeter in diameter is the same as a sphere $\frac{3}{25000}$ of an inch in diameter.

Here, then, we have two spheres, the one $\frac{1}{5}$ of an inch in diameter, and the other $\frac{3}{250000}$ of an inch in diameter. How many times is the latter sphere contained in the former?

Spheres are to each other as the cubes of their diameters. The cube of $\frac{1}{5}$ is $\frac{1}{125}$. The cube of $\frac{3}{250000}$ is $\frac{27}{1562500000000000}$.

And the former cube divided by the latter is more than 3,700,000,000. That is to say, more than thirty-seven hundred millions of these infinitely small beings might be packed within the capacity of the tiny drop.

Yet, as we shall see, these beings have all the functions of common life.

CHAPTER IV

MICROBES EAT AND EXCRETE

To say that every living being, whether plant or animal, must eat in order to exist, is only a truism. Everything that lives must struggle for existence. The struggle expends energy. The energy can be restored only by taking food. Only by eating microbes live and grow. Their manner of taking and assimilating food is peculiar. Fig. 1 represents a particle of food floating near a microbe. Fig. 2 represents the particle in contact with the microbe. In Fig. 3 a cavity is formed in the body of the microbe, and the bit of nourishment is partly drawn into it. In Fig. 4 the titbit is entirely enclosed within the body. In Fig. 5 the food is digested and assimilated all but the waste. In Fig. 6 the cavity is again formed and the particle of waste is being thrown out. In Fig. 7 the waste is entirely excreted. The opening is closed up, and the microbe ready for another meal. By this means microbes, like other living beings, grow. Fig. 8 represents different stages in the growth of one of these beings from birth to maturity.

These microbes, having no mouth, extemporize one for the occasion. Having no stomach to digest their food, they form one for that purpose. And having no organs of excretion, they likewise, in the moment of need, form them.



FIG. 1.

FIG. 2.

FIG. 3.

FIG. 4.

FIG. 5.

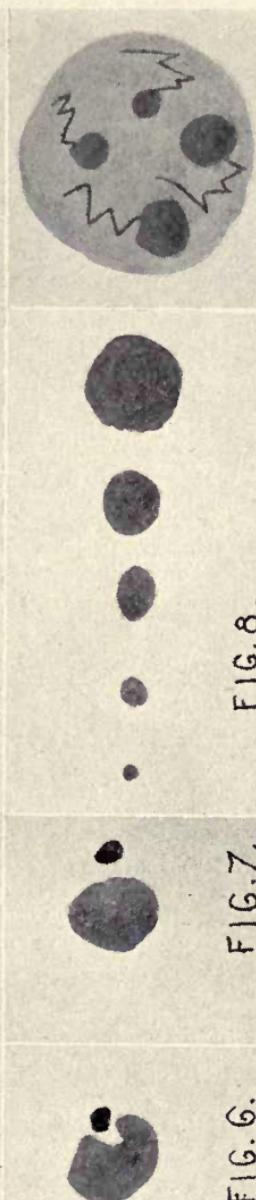


FIG. 6.

FIG. 7.

FIG. 8.



FIG. 9.

FIG. 10.

FIG. 11.

FIG. 12.

FIG. 13.

FIG. 14.

CHAPTER V

MICROBES HAVE LOCOMOTION

MICROBES have the power of motion. Sometimes they move with surprising sprightliness. In Fig. 9 are seen a number highly magnified in a drop of water. The finer lines represent their movements. They dart to and fro in all directions. They hit one another, turn about, roll over—seeming to perform all sorts of antics.

Their movements are produced by various means. Probably in the great majority of cases they move by bodily vibrations. In Fig. 10 the body of the microbe is elongated in the horizontal direction. In Fig. 11 the body is elongated in the perpendicular direction. It is plain that by such oscillation, first in one direction, then in the transverse direction, the microbe may be impelled in any desired way.

Sometimes the motions may be produced by appendages extemporized for the purpose. Fig. 12 represents the microbe without these appendages. Fig. 13 represents the same microbe with them. These appendages answer for legs. They are simply minute protrusions of the speck of protoplasm thrown out at will. They appear and disappear at the pleasure of the owner. When needed,

they are quickly shot forth from the body. When no longer needed, they are as quickly withdrawn, and disappear within the body.

A few species, however, seem to have permanent means of moving about in the shape of cilia, or minute hairs,—something at least like hairs. Sometimes a single hair at one end, Fig. 14. Sometimes a hair at each end, Fig. 15. Sometimes a tuft of hair at one end, Fig. 16. Then a tuft of hair at both ends, Fig. 17. In still other cases the tuft reaches entirely around the body, Fig. 18.

All these contrivances, like legs to the spider, tail to the tadpole, fins to the fish, or wings to the bird, enable the microbe to perform with ease all its needed movements.

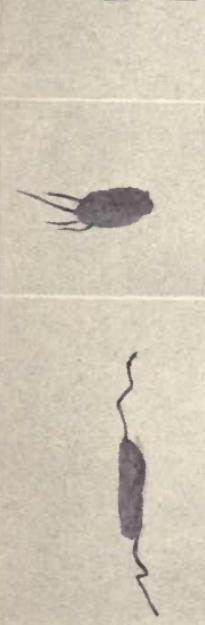


FIG. 15.



FIG. 16.



FIG. 17.

FIG. 18. FIG. 19. FIG. 19.



FIG. 20.

FIG. 21.

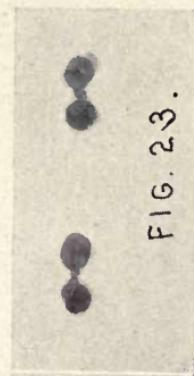


FIG. 22.

FIG. 23.

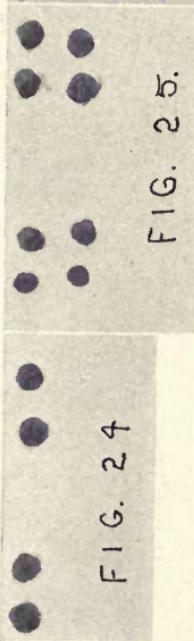


FIG. 24.

FIG. 25.

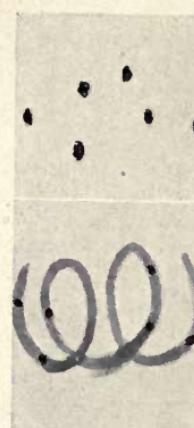


FIG. 26.

FIG. 27.

FIG. 28.

CHAPTER VI

THEY PROPAGATE

ALL microbes propagate their species. Being the simplest of living beings, they multiply in the simplest ways.

Some multiply by Fission. By this method the microbe simply divides itself into two parts, and each of these two parts becomes a new being. The two new beings then divide, each into two parts, forming four new beings. Each of these divides as before, forming eight. And so on, continually.

To understand this process more plainly, the tiny thing, as seen in Fig. 19, first increases in size and becomes elongated. Division next begins to take place, as seen in Fig. 20. The fission is finally complete as seen in Fig. 21. In Fig. 22 each of the new beings thus formed has increased in size and become longer. In Fig. 23 division in each begins to take place. In Fig. 24 the division is again complete, forming four new beings. Each of the four thus formed will enlarge and divide in the middle, as before, making eight, as shown in Fig. 25. Each of the eight will then go through the same process, making sixteen. Each of the sixteen will repeat the process, creating thirty-two. The thirty-two

will proceed in the same way to result in sixty-four. So on indefinitely.

Another method of propagation is by the Production of Spores. In Fig. 26 is represented a spiral microbe. It has no spores. Fig. 27 represents the same microbe with spores formed. In Fig. 28 the sac has disappeared and the spores are free. Each spore will develop into a microbe exactly like its parent.

Fig. 29 represents a spherical microbe. It has no spores. In Fig. 30 the spores are formed. In Fig. 31 the sac has disappeared, leaving the spores free, each to be developed into a full grown being like its parent.

In Fig. 32 is shown a rod-shaped microbe without spores. Fig. 33 shows the same shaped microbe with spores formed. Fig. 34 shows the same without the sac, each spore ready to grow into a rod-shaped being like its parent.

A third method of propagation is by Budding. In Fig. 35 the parent microbe has put forth two buds, one on either side. In Fig. 36 the buds have become full grown and separated from the parent. In place of one are now three. In Fig. 37 each of these three has again budded. In Fig. 38 the buds are all mature and separate, forming nine individuals. So the process may continue to any extent.

Fig. 39 shows how the process of budding may continue to considerable extent before separation begins.



FIG. 29. FIG. 30.

FIG. 31.

FIG. 32.

FIG. 33.



FIG. 34.

FIG. 35.

FIG. 36.

FIG. 37.



FIG. 38.

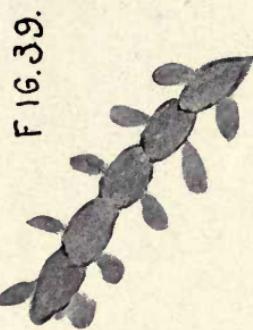


FIG. 39.

FIG. 40.

FIG. 41.

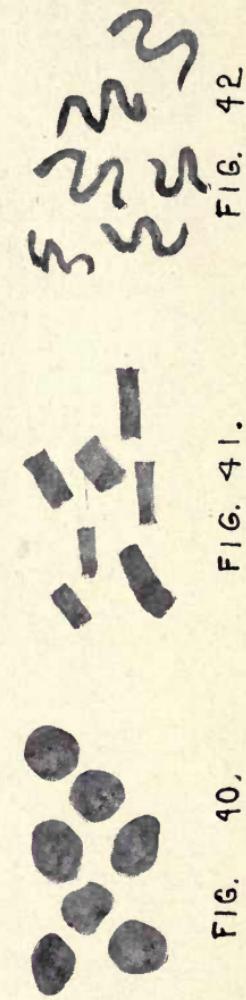


FIG. 42.

FIG. 43.

FIG. 44.

FIG. 45.

FIG. 46.

FIG. 47.

The rapidity with which, by each of these three methods, these wonderful beings reproduce their kind, is quite inconceivable. One in one day of twenty-four hours may become 16,500,000. Of course this rate of propagation could not continue without interruption. Food supply and enemies would not permit. But could this rate continue, in two days the one would become 281,500,000,000. In three days, 27,000,000,000,000. It has been estimated that this number weigh about 10,000,000 pounds or eight thousand tons!

CHAPTER VII

THEIR ONENESS OF ACTION

To propagate with such lightning rapidity must of course require not a little energy. That such infinitely small beings should have such energy, is the wonder. But it may be because of their oneness of action — throwing their whole being into every motion. Having no differentiated organs, whatever they do they do with their whole being. Having no lungs, with their whole being they breathe. Having no mouth, with their whole being they eat. Having no stomach, with their whole being they digest. Having no organs of assimilation, with their whole being they assimilate their food. Having no organs of secretion, with their whole being they secrete. Having no nervous system, with their whole being they feel. Having no brain, with their whole being they think. Having for the most part, no organs of locomotion, with their whole being they move. And having no organs of propagation, with their whole being they propagate. Thus throwing every atom of their whole energy into every motion, that motion is quick and effectual.

CHAPTER VIII

THEIR NUMBERS

IN Nature there is perhaps some mathematical ratio between size and numbers. Anyway, the greater the size, the smaller the numbers; the smaller the size, the greater the numbers. How few the worlds seen in the heavens compared with the grains of sand on the seashore; the great forest trees compared with the spears of grass which cover the earth; the mammoths compared with the myriads of insect life teeming everywhere. So we are prepared to see that microbes being so much smaller than all visible plants and animals out-number them all as many times as they are smaller — they literally swarm in the air, the water, the soil.

Like all other plants and animals, they inhabit more densely those localities where their food supply is more abundant. Impurities to us are food to them. Hence the impure air of populous cities contains more microbes than the purer country air, the air of the high mountains or on the high seas. But so densely populated is the air generally that it is estimated that with every breath we draw into the lungs not less than 300,000 of these beings.

The soil contains them in greater numbers. In

one ounce of soil, depending on its condition, are found from 7,000 to 7,000,000,000. It is estimated that every ounce of soil on the land surface of the earth to the depth of four feet, contains, on the average, about 10,000.

Water is quite as favorite a dwelling place for these beings. A quart of water just condensed from vapor contains 1,000. A quart of rain water, 7,000. A quart of spring water, 200,000. A quart of ordinary river water, 1,500,000. A quart of river water just below a populous city, 13,000,000. A quart of sewer water, 100,000,000.

In all the air, soil and water of the earth, what a universe of these unseen beings. Count up every living thing in the visible world,— all the trees of the forests, grasses and flowers of the field, fishes of the seas, birds of the air, reptiles and worms that crawl, animals domestic and wild, and all the insects teeming everywhere,— add all these numbers together, and you will need to multiply the result by millions upon millions, to equal the numbers of microbes.

CHAPTER IX

DIFFERENT KINDS

IN the Visible World, as everyone knows, the Animal Kingdom is divided into two sub-kingdoms, the Vertebrate and the Invertebrate; and the Vegetable Kingdom into two sub-kingdoms, the Flowering Plants and the Flowerless Plants. But in the Invisible World the Microbian Kingdom, as already indicated, is divided into three sub-kingdoms, the Spherical, Fig. 40, the Rod Shaped, Fig. 41, and the Spiral Shaped, Fig. 42. And, like the sub-kingdoms in the Visible World, the sub-kingdoms in the Invisible World are divided into families, classes, orders, genera, species, individuals, and the individuals into endless varieties. Into these different kinds the infinite multitude of microbes may be classified. No two are exactly and absolutely alike.

Likewise, in the Visible World, every kind reproduces only its own kind; man reproduces only man; the lion reproduces only the lion; the oak only the oak. So in the Invisible World the Spherical microbe reproduces only the Spherical, the Rod Shaped only the Rod Shaped, and the Spiral only the Spiral. Through all the lower divisions of these infinitely small beings, also, each kind reproduces only its own kind.

Like plants and animals in the Visible World, microbes occupy the whole earth. Some are adapted to the intense heat of the equator, others to the milder heat of the tropics, and others to the intense cold of the polar regions.

Another thing: It was stated in the last chapter that the larger the individuals, the fewer the numbers; and the smaller the individuals, the greater the numbers. It may also be noted that the higher the order the less the numbers; and the lower the order the greater the numbers. The individuals of the human race must be multiplied many times to equal the number of animals below them. All the animals of the Animal Kingdom must be multiplied millions of times to equal the number of living things in the Vegetable Kingdom. And in the Microbian Kingdom the living beings outnumber by millions upon millions of times all the living beings above them, both in the Animal and Vegetable Kingdoms. As we go up in the great Scale of Life, the numbers decrease; as we go down, they increase.

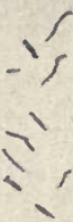
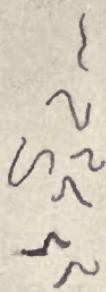
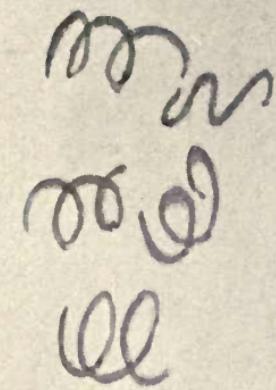


FIG. 45

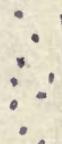


FIG. 44.

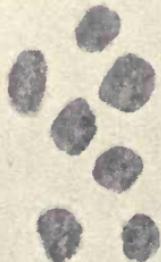


FIG. 43.

CHAPTER X

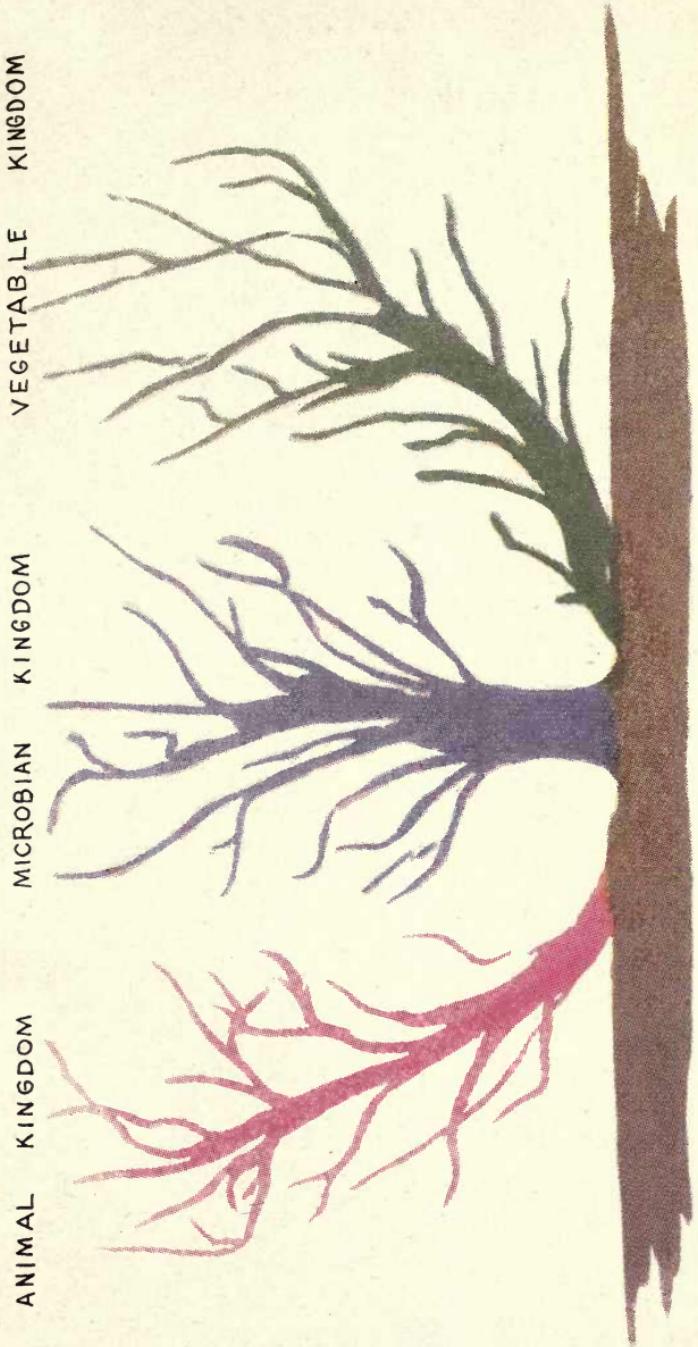
THEIR PLACE IN NATURE

IN the endless chain of Evolution of life on the earth it is easy to place microbes. They are themselves a part of that evolution — the first part. They are the connecting link between all other life above them and the mineral below them. Imagine the tiniest possible speck of protoplasm. It is the first speck of life on earth above the mineral. The word protoplasm means "first life." From this speck may be traced three distinct lines of evolution, severally ending in the complete development of the three general types or sub-kingdoms. Fig. 43 shows different stages in the evolution of the first type. The first stage is the tiny speck of protoplasm. It is microscopic — millions of times smaller than the tiniest drop of water. The substance is jelly-like, and has no envelope or covering.

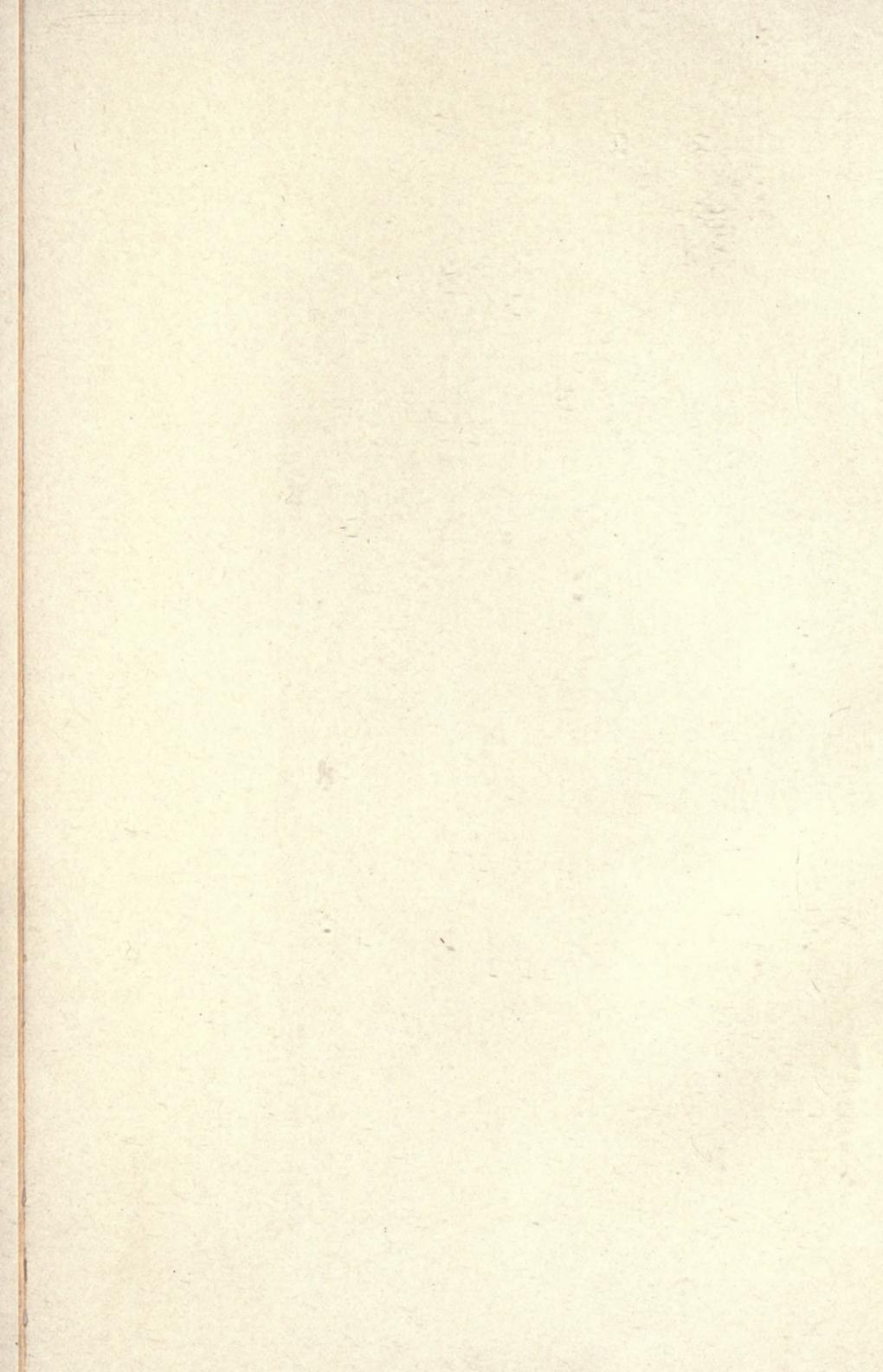
In the second stage the tiny speck has multiplied, and its offspring are larger. In the third stage the individuals are fully developed and have an envelope. In the fourth stage they have acquired the power of extemporizing legs for locomotion.

Fig. 44 shows four similar stages in the evolution of the Rod Shaped type and Fig. 45 shows the four stages in the evolution of the Spiral Shaped type.

The original speck may have been single or millions. It matters not. The different types and forms are no doubt owing to the different kinds of environment and the survival of the fittest. Long intervals of time must have elapsed between its successive stages, and long ages required for the complete evolution of this Kingdom of Life. The place in Nature may now be illustrated by Fig. 46. As this shows, the root of all organic life springs from, and is nourished in, the Mineral Kingdom. From this root is first developed the Microbian Kingdom; and, then on the one hand, the Vegetable Kingdom, on the other hand, the Animal Kingdom. The Microbian Kingdom thus lies below and between the other two Kingdoms.



TREE OF LIFE
FIG. 46.



CHAPTER XI

GOOD AND BAD

WHATEVER other divisions of microbes may be made, that which most concerns mankind is their division into Good and Bad. The Good are those which render to us a good service. The Bad are those which render to us a bad service. Happily, the great bulk of all micro-organisms help us. Their service is only good. Indeed, they are essential to our very existence.

Every one who thinks of it for a moment, must see that in the Visible World all the infinite multitude of living beings, both animal and vegetable, are needful to man's existence. He could not live on the earth without them. The same is true of all living beings, both plants and animals, within the Invisible World. With a few important exceptions,—as will be seen in future chapters of this work,—these beings are essential to our existence on the earth.

These beings assist in all forms of agriculture. Many crops could not be grown without them. Even the vast beds of coal which now furnish the world with fuel probably could not have been formed without them.

Their service is indispensable to the dairyman. For the fine flavor of his butter and cheese he is

indebted to the microbe. These articles, without the aid of our Invisible Friends, would disappear from our tables the world over.

Likewise for alcohol in all its forms, including all alcoholic drinks, the world is indebted to the microbe. Vinegar without them would also be unknown.

But microbes not only render needful service in building up and preserving all good things for man, but they also render essential aid in tearing to pieces, dissolving and destroying all bad things. Without their aid, dead bodies, both plants and animals, would not decay, but encumber the ground, finally making it impossible for man or beast to exist. But with their aid all vegetable and animal bodies left on the earth soon decay, are dissolved into gas, and the gas goes to form new vegetable and animal bodies; thus the earth is continually renewed, and kept clean, sweet and wholesome for man and beast.

On the other hand, as will be shown later on in this work, the few kinds of bad microbes are our deadliest enemies. They are the active cause of all the contagious and infectious diseases in the world. They cause the death of not less than thirty million persons every year. Every year they attack and cause the sickness and great suffering of more than thirty millions more. Thus these Invisible Foes cause more sickness, suffering and death to mankind every year, many times more, than all other causes combined.

CHAPTER XII

MAY BE CULTIVATED

EVERY one knows that all domestic animals,—horse, cow, sheep, dog, and the rest, including all domestic fowls,—were once wild—at least their ancestors were wild. Man has captured, tamed and domesticated them. By long processes of culture he has greatly improved and added to them many new species and varieties.

Every one knows, too, that all our domestic plants,—corn, wheat, oats, rye, barley, and the rest, including all our vegetables, and flowers from the garden,—were likewise once wild. Man has transplanted and domesticated them. From times immemorial he has cultivated them, and by the long processes of natural selection he has multiplied many times the original species and varieties whence they came, and greatly improved them all.

But not every one knows that man sustains a similar relation to micro-organisms. Such, however, is the fact. In their original state they, too, in a sense, are wild. They, too, may be captured and domesticated, the good becoming better, the bad, if possible, worse. From time immemorial the baker's yeast, in the solid or liquid form, has been a culture for the microbes of bread. From

time immemorial the wort carried by the brewer from brewing to brewing has been a culture for the microbes of beer.

Until recently all such work was done unwittingly. The baker did not know that the yeast which he used was literally alive with the invisible beings which we now call microbes, and that to the work of these beings he was indebted for the fine qualities of his bread; nor did the brewer know that the wort which he carried from brewing to brewing was likewise filled with similar beings, and that to them he owed the fine flavors of his beer. But by the recent invention and use of the microscope, and other means, all is now plain; and such work is done intelligently.

Originally, therefore, the first brewings of beer could have been made only by the aid of wild microbes which came into the wort from the atmosphere. How long this continued we know not. But at length, either by accident or experiment, wort from one brewing must have been transferred to the next, and from this to the next, repeating the process many times. When it was found that better results were obtained, this method finally became habitual. The microbes were at first wild. They then became domesticated. Then by long processes of culture they became greatly improved, and now do their excellent work for the world.

A similar history must of course be supposed to be traced in the development of breadmaking. The microbes causing the first ferments were wild. At

length a bit of the fermenting batter was carried from baking to baking. The microbes were thus domesticated. Good results followed. Finally it was discovered in some way how from the ferment to form yeast. Then by centuries of culture the microbes have been greatly improved, and now seemingly do their best work for the world.

No doubt, in the future, still more and more improvement will be made along both these lines of culture.

Meanwhile, corresponding work is being done in the dairy and in agriculture. Here, too, the wild microbes must go, and the domesticated come. The process is simple. Isolate the true microbe for butter and the true microbe for cheese. Make of these microbes pure cultures. Inoculate the cream for butter with the butter culture, the milk for cheese with the cheese culture. The microbes under domestication will thus get the start of the wild ones coming in from the air. Be persistent in this method. Better and better results will follow.

At length find a way to make of the right microbes a true butter yeast and a true cheese yeast. In butter-making and in cheese-making use these yeasts as bread yeast is used in bread-making. This will finally mean finer qualities in all dairy products the world over.

Certain crops cannot be raised on certain lands because the kind of microbes necessary for the growing of these crops is absent from the soil.

Millions of acres of such lands now lie idle and useless. But isolate the right kind of microbes—that is, separate them from all others. Make of these microbes pure cultures—that is, cultures containing these microbes only. Make the cultures in the dry form. Reduce them to powder. Mix the powder with the seed and sow it. The germs will rapidly multiply, completely fill the soil, do just the kind of work needful for the seed to germinate and grow, and abundant crops will be the result.

On the other hand, the bad microbes may be cultivated either intentionally for a good purpose, or unintentionally, producing bad results.

Isolate the microbe of typhoid fever, taken from the human subject having that disease. Make of it a pure culture. Inject a bit of the culture, hypodermically, into the circulation of some susceptible lower animal, like the guinea pig or the rabbit. The animal will have the fever.

Repeat the same experiment with the microbe of diphtheria, scarlet fever, and so on with all the contagious and infectious diseases. In every instance the germ in the culture produces the same disease in the lower animal which the human subject has from whom the germ is taken.

This is striking proof that in every case the microbe is the cause of the disease, and the only cause. And this knowledge is vitally important because, knowing the cause of the disease, one is

better enabled to manage and control it,—or, what is infinitely better, to prevent it.

But the pathogenic germs are only too often cultivated unintentionally, with only bad results. The good microbes thrive best in cleanly cultures. The more cleanly the bouillon, beef tea, or other substance in which they are multiplied, the better. But the bad microbes seem to require the very reverse conditions. They thrive best in uncleanness. For them the bad water of stagnant pools and ponds, or of rivers,—especially below villages and cities,—is a good culture. The bad air, too, of crowded theaters, churches, ill-ventilated shops and sleeping rooms, is a good culture for these Invisible Foes. Likewise every decaying vegetable in the cellar, every crumb of moldy bread in the cupboard, every sour dish towel, unclean sink, foul drain or water closet,—all uncleanness in one's home or about the premises, is yet an excellent culture inviting to the home the deadliest enemies of mankind.

“True, 'tis pity,
And pity 'tis, 'tis true.”

PART II

MICROBES AND LIFE

CHAPTER XIII

A LITTLE CHEMISTRY

ALL the matter in the universe is composed of molecules. All the molecules are composed of atoms, or the chemical elements. All the atoms are composed of electrons, or electrical points. These electrons are probably connecting links between the atoms and the Ether. The Ether is probably the original source whence the entire universe of matter has sprung.

Anyway, the Ether, as exploited by science, is an infinitely fine substance; the fineness of its texture is beyond the power of imagination to conceive. An infinitely tenuous and elastic medium; its rarity cannot be excelled, its normal state cannot be changed. The dimensions of the Ether are also infinite. It fills all space. It penetrates and saturates alike all the hardest and all the softest bodies of the universe. It flows in among the atoms of, and saturates, a diamond or a world, as readily as water flows in among the fibers of, and saturates, a sponge.—An infinite ocean of Some-

thing by which all worlds are saturated and in which all worlds seem, as it were, to float.

In the present state of knowledge the different kinds of atoms, or chemical elements, are eighty in number. They combine with one another to form the different kinds of molecules according to their relative weights. The atom of hydrogen is the lightest. Take this as the unit of measure. Call it one. The atom of carbon is six times as heavy as the atom of hydrogen. The combining number is therefore, 6. The atom of oxygen is eight times as heavy, therefore its combining number is 8. The atom of sulphur being sixteen times as heavy, its combining number is 16. For a similar reason the combining number of the atom of iron is 28; of mercury, 100; of silver, 108. And so on to the heaviest atom, which is bismuth. Its weight is two hundred and ten times that of hydrogen. Its combining number is therefore 210.

In combining to form molecules, the atoms are never broken. Only whole atoms, or multiples of the same, combine with whole atoms. Molecules, thus formed, give character to all the different kinds and masses of matter in the universe. Two atoms of hydrogen unite with one atom of oxygen to form the molecule of water. All the water in the universe is composed, and must be composed, of just such molecules. Every molecule of all the carbon dioxide in the universe is composed of exactly three atoms—two of oxygen united with one of carbon. All the pure alcohol in the world

is made up of molecules, each of which contains precisely twelve atoms — four of carbon, six of hydrogen and two of oxygen.

Hence chemical symbols. Each kind of matter is represented by some letter or letters of the alphabet. C represents carbon, H hydrogen, N nitrogen, O oxygen, and so on. If the molecule contains more than one atom of the same kind, the number is indicated by a little numeral at the right and bottom of the letter. Thus, H_2O is water; CO_2 carbon dioxide; $C_2H_6O_2$ alcohol.

Every form of matter in the universe takes its peculiar character from the molecules of which it is composed, and the molecules take their peculiar character from the atoms composing them.

The number of atoms in the molecule varies from two or three to over one thousand. The molecule of water has three atoms; the molecule of protoplasm has over one thousand.

The size of the molecule is almost infinitely small — not more than the one fifty-millionth of an inch in diameter. That is to say, fifty millions of these minute bits of matter, placed side by side, would form a line not more than an inch in length.

The atoms which compose these small bodies are, of course, much smaller — at least twice as small. To form a line one inch in length would require, at least, one hundred million atoms.

But small as these bodies are, the electrons are thousands of times smaller. It is estimated that the mass of matter contained in one electron is a

thousand times less than that contained in the atom of hydrogen. If this is true, then it follows that the combining number of any one of the other atoms expresses in thousands the number of times the weight of the electron is less than the weight of that atom. Thus, the weight of the electron would be eight thousand times less than the weight of the atom of oxygen; twenty-eight thousand times less than the weight of the atom of iron; one hundred thousand times less than the weight of the atom of mercury; and two hundred and ten thousand times less than the weight of the atom of bismuth.

Yet all these electrons are probably composed of still smaller bodies, and these smaller bodies of bodies smaller still, and so on, until the descending series coalesces with the Ether.

CHAPTER XIV

A LITTLE PHYSICS

THE law of Universal Gravitation is the prime factor in running the machinery of the universe. It means that each one of the one thousand million larger bodies composing the universe attracts, and is attracted by each one of all the others, by a pull the force of which is directly as the mass and inversely as the squares of the distances. By this mighty power all these millions of bodies are kept in their exact places, performing their motions from age to age with the regularity and precision of perfect clock work.

The Earth completes its rotation on its axis at the same instant every day, and performs its revolution around the sun with the same precision. All the other planets rotate on their axes, and complete their journeys around the sun, in similarly exact times. The sun itself, too, rotates on its axis, and is moving at a rapid rate — taking along with it all the planets, comets, asteroids and meteors in its system — towards some point in Hercules.

A hundred million bright stars look down from the night sky. Each one is a sun. Each sun is the center of a solar system. Planets, comets, asteroids, and meteors galore, compose each sys-

tem. All these bodies, great and small in all the systems, are parts of the universe. They all rotate on their axes. They all travel in their orbits around the central suns. All these suns roll on their axes, and each with its entire system is executing a translatory motion in space towards some point in the universe.

All these heavenly bodies are held in their places, and all their motions are caused and necessitated, by the mighty power of gravity.

The medium in, and by, which this force acts, — the medium which makes it possible for the most distant bodies in the universe to attract each other and all the rest, and all the rest to attract them, — is doubtless the infinite Sea of Ether. Light, electricity and magnetism also move through this medium at the rate of 196,000 miles per second, and exert an influence in working out the destiny of the universe coequal with that of gravity. The giant force of heat adds its service in determining the state of all the matter in the universe, whether it be gaseous, liquid or solid.

But the infinitely great is made up of infinitely littles. As before stated, the great masses of matter composing the universe are composed of infinitely small molecules not more than $\frac{1}{50000000}$ of an inch in diameter. The molecules are composed of still smaller bodies called atoms not more than $\frac{1}{10000000}$ of an inch in diameter. The atoms are composed of bodies smaller still, called electrons, not more than $\frac{1}{10000000000}$ of an inch

in diameter. It is wheel within wheel from the greatest to the least. The forces which run the machinery of all the infinitely small worlds work out results with as much regularity and precision as do the forces which run the machinery of the infinitely great worlds.

The spaces between the heavenly bodies are much larger than the spaces occupied by the bodies themselves. So the spaces between the molecules which compose the masses, between the atoms composing the molecules, and between the electrons composing the atoms, are severally much larger than the spaces occupied by these bodies.

The heavenly bodies are cemented together and held in their places by gravitational attraction; the molecules are cemented together and held in their places in composing the heavenly bodies by molecular attraction. The atoms are cemented together and held in their places to form the molecules by electric and magnetic forces; and the electrons are cemented together and held in their places to compose the atoms by the same forces.

All the heavenly bodies composing the universe rotate on their axes, revolve around centers, and have free motions in space. So the molecules within, and forming all these, heavenly bodies rotate, revolve around centers, and have free motions in space; so the atoms within the molecules vibrate, rotate, revolve, and have free motions; and so the electrons jostle about, rotate, revolve, and have free motions in space. Of course all the move-

ments of these tiny worlds are infinitely small, but they are none the less real than the movements of the largest bodies in the universe.

In the heavens are seen double stars revolving around one another, constellations, star clusters, and nebulae. So among the infinitely little worlds are double atoms in the molecules, perhaps revolving around one another; triple atoms, as in the molecule of water; other molecules containing more and more atoms up to a constellation of more than a thousand in the molecule of protoplasm; and clusters of electrons in atoms, numbering thousands or even millions; while a group of electrons moving freely in space might present something like a nebulous appearance.

One thing more. It seems that the motions of the stars, or suns, in the universe are such that two suns may occasionally meet. The meeting involves all the bodies in the two solar systems. At the moment of collision they must both be moving at the rate of not less than four hundred miles per second. The collision generates heat enough to dissolve all the bodies in each system into free molecules, the molecules into free atoms, and the atoms into free electrons. The electrons then being probably but a vast bunch of electric atoms may dissolve into the Ether. So the motions of the electrons within the atoms may be such that collisions occur. Explosions follow. This sets free the electrons. Billions of these infinitesimal atoms emanate into

free space. This is radioactivity. These billions of electrons are but so many atoms of electricity. While dissolving into the infinite Sea of Ether, they both cause and explain the phenomena of the so called X-rays, Alpha-rays, Beta-rays, and Gamma-rays.

CHAPTER XV

THE ORIGIN OF MATTER

OTHERS may know; here it is guess. But we guess the guess is right! Positive statements pass for what they are worth.

One thing is certain: Evolution and Dissolution are complements of one another—two parts of one whole. Everything from the least to the greatest throughout the universe comes to exist by Evolution. Everything from the least to the greatest throughout the universe sooner or later ceases to exist by Dissolution. By Evolution the tiny flower blossoms its little hour, and by Dissolution returns whence it came. By Evolution the greatest world lives its allotted time; by Dissolution it goes back whence it came.

So with every least and every greatest thing in the universe;—Dissolution follows Evolution as night follows day. Dissolution is forever tearing down what Evolution builds up.

By Evolution portions of the infinite Sea of Ether forever develop into electrons, electrons into atoms, atoms into molecules, molecules into nebulæ, nebulæ into worlds and systems of worlds.

By Dissolution two eternal streams of Matter, — one from the infinitely great by the clash of

worlds and systems of worlds, the other from the infinitely little by the clash of atoms and the consequent radioactivity,—flow back to, and unite with, the Infinite Sea of Ether.

The chemical atom has a most complex system. Within it thousands of electrons rotate, revolve around a center, and perform other motions with lightning rapidity. Sometimes there is clashing. Explosion follows. The electrons are hurled into free space, and, by further reduction, coalesce with the Ether. It is probable that this radioactivity is, in some degree constantly taking place throughout the universe.

On the other hand, two solar systems clash into each other. All the matter in both systems is almost instantly reduced to electrons, and finally to the Ether. Somewhere in the immensity of space this process, too, may be forever taking place.

In each case, therefore, there must first be Evolution. The atoms must be evolved before they can be dissolved. The systems of worlds too, must be built up before they can be torn down.

Whence, then, comes the matter for all this building up? Of course it can only come from that infinite storehouse to which it is consigned — the Ether. Just how the Evolution takes place, we may not know. But we may at least guess. The guess is short and simple. Somehow, clouds of electrons are born of the Ether and set up in vortex rings. Different numbers of electrons compose the rings. Some have more, some have less.

The arrangement of the electrons within the rings is also varied. The rings are all exceedingly complex, but some may be more complicated than others.

Hence come the different kinds of vortex rings — eighty or more in number. They are the chemical elements. By virtue of magnetic and electric forces these atoms are locked together in molecules. The molecules are attracted together and form nebulæ,—vast bodies of gas. Ten thousand or more of these bodies are now mapped on astronomical charts. Millions more exist. They are the raw material out of which, by the further processes of Evolution, solar systems, constellations, star clusters and milky ways are manufactured.

Thus the Ether is the storehouse of infinite energy. Out of this storehouse by Evolution and transmutation comes the matter of the material universe. By Dissolution matter is constantly returning.

Here is the Great Cycle. Thousands of other and smaller cycles are traced in all departments of the material world. In a thousand ways matter appears in certain forms, disappears only to reappear in the same or similar forms. But from the Ether to worlds and back again, is the cycle which, in a sense, includes all other cycles.

CHAPTER XVI

ORIGIN OF THE MICROBE

THE last three chapters prepare one now to consider that all life originates, like all matter, in the Ether. Life ebbs and flows with matter. There can be no matter without life,—life either in its actual or potential form. Nor can there be any life without matter, either in its actual or potential form. Life and matter go together. Neither exists without the other. The Evolution of the matter of the universe is also the Evolution of the life of the universe.

With these facts as a basis, it is easy to trace the origin of the microbe. Under certain conditions, we may imagine that, from the Ether, at certain points in the universe, vast showers of electrons are precipitated in some such sense as mists are precipitated from the atmosphere. Then, by further Evolution, these great assemblages of electric atoms may be set up into vortex rings, or chemical atoms. Each chemical atom is a most complex system, composed of thousands of electric atoms revolving with lightning rapidity around a common center. These chemical atoms have certain affinities for one another, or are attracted together by electric and magnetic forces,

into molecules. These molecules form the nebula — a vast body of gaseous matter.

Now, during the further Evolution of the nebula into the solar system, there comes a time when the atoms so unite in molecules as to form air, water and minerals. Finally the atoms so unite in molecules, — more than a thousand in each, — as to form the first speck of protoplasm. It is the first microbe, the first form of organic life on the earth.

It matters not whether one, a few, or vast numbers are at first produced; they generate so rapidly that, in any event, they soon spread over the earth. By the processes of natural selection and the survival of the fittest they finally differentiate into varieties, species, genera, families and classes, — much as they exist on the earth to-day.

CHAPTER XVII

THE PSYCHIC FACULTY OF MICROBES

By psychic faculty is meant the power to know. It is easy to see that microbes have this power. It may be infinitesimally small; but it is real all the same.

For instance, in obtaining their food they exercise the power of choice. They get their food by coming in contact with it. When they come in contact with a particle of vegetable or animal substance which is proper food, they extemporize a mouth, engulf and digest it. But coming in contact with a mineral particle which is not proper food, they avoid and reject it. This is choice. They choose one particle, and reject the other. They could not make the wise selection without knowing the difference between the two particles. Only a psychic faculty could do this.

Another illustration of the same thing is seen in the actions of the higher micro-organisms which copulate. The male seeks the female very much as the rooster seeks the hen. To make the parallel complete, the female microbe shys and pretends to run away from the male, very much as the hen shys and pretends to run away from the rooster. Frequently, before coition takes place, the male and

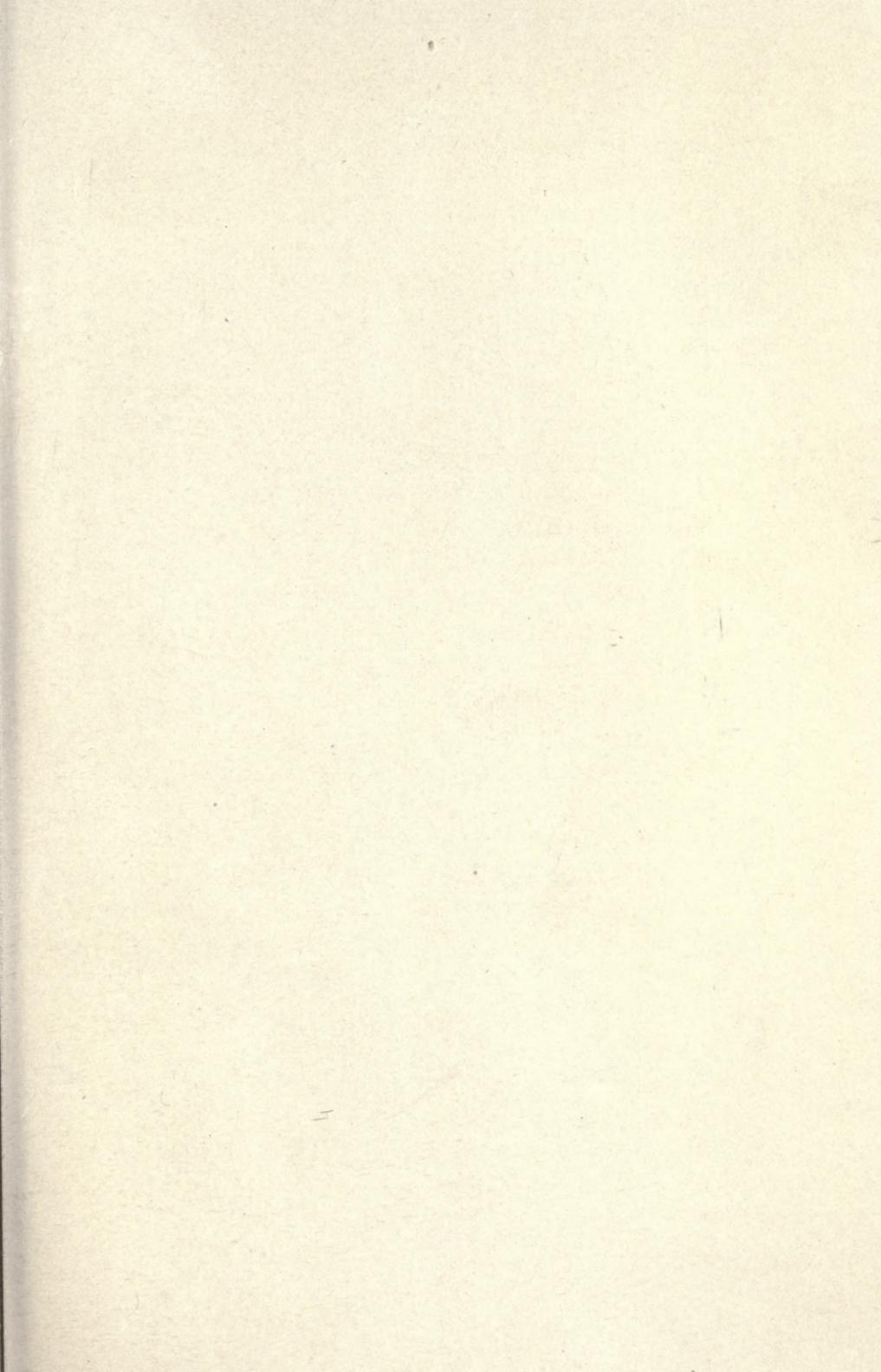
female microbe perform many other such antics. In this respect they seem to resemble all the higher animals, including the human. Nothing but a psychic faculty can account for this.

It would seem, therefore, that the being endowed with the very lowest and tiniest form of life on earth, yet possesses a faculty the same in kind with that of all higher forms of life, including man. This capacity for thought in the microbe may be as much smaller than it is in the human being as the microbe is smaller in stature than the human being,—as much simpler as the organism of the microbe is simpler than the organism of the man,—yet it is absolutely the same in kind. It follows, therefore, that, inasmuch as the microbe, by a long process of Evolution reaching through the ages, has come from the ether, the ether itself must contain the original psychic principle, else by no process of Evolution could the psychic faculty be developed from the ether. The germ of the intellect must be contained in the fountain head, else no intellectual result can flow therefrom.

In a nutshell: Matter must exist potentially in the Ether, else worlds could not be evolved therefrom.

Life must exist potentially in the Ether, else by no process of Evolution could come therefrom all the living beings on the Earth.

Thought must exist potentially in the Ether, else from it could not be developed all degrees of intellect from the microbe to man.



THE MICROBE of BEER

BUDDING.

FIG. 48.

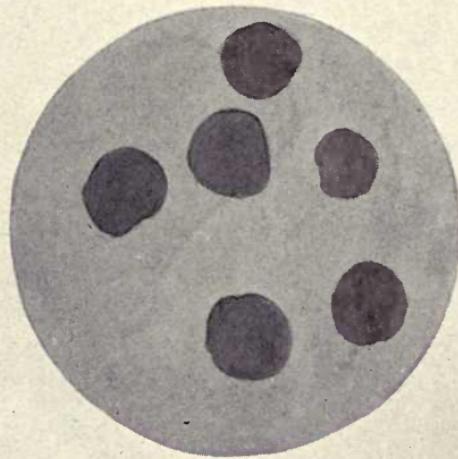


FIG. 47.

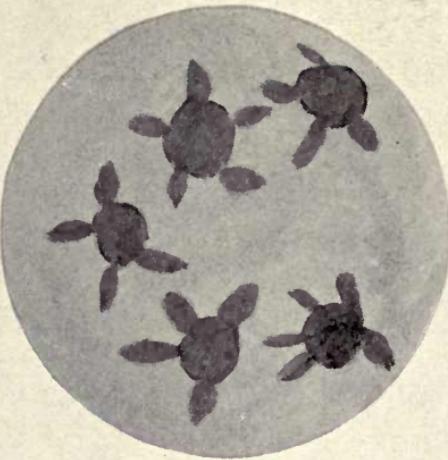


FIG. 49.



CHAPTER XVIII

THE CELL AS A MICROBE

THE cell, like everything else in the universe, is a thing of Evolution. In its primal form it consists of a minute particle of matter resembling jelly.

At a second stage, within this particle, and diffused through it, are exceedingly fine granules.

At a third stage, the particle is surrounded by a membranous covering, and at its center is developed a round kernel called the nucleus, which is larger than the granules.

At a later and final stage appear within the nucleus certain tiny dots called nucleoli; also a certain network consisting of fine threads variously woven together. Because this network may be stained with coloring matter it is called chromatic.

In Fig. 47 are represented all these steps in the evolution of the cell; from the minute particle to the full grown cell; with all its organs completely developed.

But the cell, thus complete, is so minute that no unaided eye has ever seen it, or ever will see it. Only a powerful microscope can reveal it. Yet it possesses a wonderful twofold power.

First, it is able to seize hold of matter outside of, and very different from, itself, to digest, absorb and transform this matter into matter like itself. By this means the cell grows.

Second, the cell is able to propagate, or to produce another bit of matter just like itself.

So long as the cell exists, it seems to exercise this twofold power continually. It assimilates other matter to itself, and grows, until it becomes about twice its normal size. In growing it becomes double in all its organs. Then it divides into two equal parts, and each part becomes a perfect cell. These two cells grow and divide as before into four cells; these four into eight; these eight into sixteen; these sixteen into thirty-two; and so on, until the end in view is accomplished.

Consider now that every complex organic Body, be it plant or animal, is composed of cells, and springs originally from a single cell. This original cell comes itself from the cell of a previous plant or animal. This new plant or animal begins its life with this single cell. The cell grows, divides and multiplies — as already explained — adding cell to cell until the new plant or animal is fully grown in all its parts. Besides, this single cell is so endowed by its parentage that in growing, multiplying and producing the new plant or animal, this new plant or animal is exactly in kind and form the same as that parent from which this first cell is derived.

With a certain plan in mind, the architect lays

the first stone. Stone after stone is so fashioned and joined to the first — using many different kinds for the many different parts of the building — that when the final stone is laid, the temple in all its parts is finished completely in harmony with the original plan.

So Nature, with a certain plan in view, lays the first cell. Nature makes this cell its own architect. The plan is Nature's plan. This cell creates and joins to itself another cell like itself. These two cells create and join to themselves two more. These four, four more; and so on, until the plant or animal is complete. Cell after cell is so fashioned and joined to the first, — different kinds being created for different parts, — that when the last one is added, the plant or animal, in all its parts and organs, is built up and developed according to the ideal in view.

Consider, too, that the cell is not only the unit of structure, but that it also is the unit of life. It is itself a throb of life — the first form of life. The bit of matter composing the cell, and having such wonderful properties, is rightly named — protoplasm. The word means the first form of life. The first speck of protoplasm on the earth was the beginning of organic life on the earth. By repeating this speck, all forms of this life on the earth have been developed and built up.

Therefore, as every plant or animal on the earth is composed of tiny bits of protoplasm pent up in minute sacs, and as every one of these bits is a

thing of life, the collective life of all the cells of any one plant or animal is the whole life of that plant or animal. And as the entire vegetable and animal kingdoms are built up with these tiny bits of protoplasm, it would be plainly possible, by estimating at any time the approximate number of cells on the earth, to determine thereby the approximate volume of life on the earth.

But the object here in view is to think of the cell, in all this volume of life, as a microbe. It has so many properties similar to, if not identical with, those of the microbe, that one seems compelled to think of the cell as a being not only resembling, but often the same as, the other being.

The two beings in their primitive form consist each of a tiny bit of protoplasm. In this respect they certainly are alike, if not identical.

By virtue of this the two beings have each the power to seize hold of other kinds of matter, to digest this matter and transform it into protoplasm, and thus to make it a part of themselves. In this respect the two beings are identical. Each is a manufacturer of protoplasm.

The two beings are alike in the organs which, sooner or later, appear in each. Each has, or may have, the nucleus, the granules and the protective membrane.

The two beings are similar in respect to size. Each is microscopical — far too small to be seen by the unaided eye.

Cells, like microbes, vary in size. Some are so

small as to require 1,728,000,000 to make a cubic inch. Others are many times smaller. Between the extremes the variety in size is endless.

Cells resemble microbes in form. They are Spherical, Rod-shaped and Spiral. Under each of these three general types the variation in form is endless. Every part of every plant and every part of every animal is built up with its own peculiar kind of cell, and in each part the kind is varied indefinitely to suit circumstances.

The cell takes its food as does the microbe—absorbs it through its membranous coverings. It digests in the same way, decomposing before absorbing its food.

The cell grows and multiplies in the same way as does the microbe. The two beings increase alike in size until about twice their normal size, then divide into two equal parts. These two new beings increase and divide as before, and so on indefinitely.

As every microbe comes from a previous microbe, so every cell comes from a previous cell; and, like the microbe, a single cell may multiply itself into many millions in twenty-four hours.

The cell enjoys locomotion in a similar way and by similar means with the microbe. Some cells, like some microbes, are stationary but have vibratory motions. Other cells, like other microbes, move freely about from place to place. The blood cells, or corpuscles, circulate rapidly with the blood through the whole system. And millions of

plants, and millions of animals, are unicellular, and, as microbes, move freely about at will.

All cells, like all microbes, in their life processes develop certain chemical products. The most of these products, like most of the products developed by microbes, are wholesome. All the nutritious juices of animal foods are produced, or, at least, enriched and flavored, by the cells of the animal. So all the nourishing qualities of vegetables, grains and fruits which help form a wholesome diet, are produced by plant cells.

But some cells, like some microbes, manufacture poisons. As the poisons which cause all the contagious and infectious diseases are created by certain microbes, so the poisons of the tarantula and other insects, of the rattlesnake and other reptiles, are created by the cells of these animals; and likewise the poisons of the ivy, the nettle, the sumach, and other herbs, are generated by the cells of those plants.

Like microbes, cells eat without a mouth, digest without a stomach, feel without a nervous system, propagate without sexual organs, and move, some with, and some without, organs of locomotion.

The cell too, like the microbe,—but in a higher degree,—forms itself into communities, and each community acts with a special purpose in view, and also with a general and higher purpose shared by the whole.

Individuals of some one species of microbe,—and of one species only,—form a colony by them-

selves. In some cases the members are tied together by a kind of gluey substance manufactured for that purpose. Each member is assigned its place in the colony, and is a kind of fixture at that point. They all work together, however, and do the same kind of work, with the same plan in view. The entire colony is enclosed by a textile covering, to preserve the colony, confine it within certain limits, and to enable it to act as one body.

Practically, the same thing takes place in the service rendered by microbes in the useful arts. Each industry which depends upon their work is an example. In brewing beer, for instance, the wort is first inoculated with the right species of microbes by a yeast taken from a previous brewing. They multiply and occupy every particle of the liquor. They are now one colony or community. The boundaries of the liquor are the boundaries of the community. All other micro-organisms are practically kept out; while all the members of this exclusive community do one and the same kind of work for the brewer;— in subsisting on the sugar of the wort they generate alcohol and carbon dioxide which give vim and flavor to the beer.

The same thing happens in making alcohol, wine, cider, or any other kind of alcoholic drinks; also in making vinegar, butter, cheese; in tearing in pieces dead animal or vegetable bodies, that their atoms may go to nourish new forms of life, and

thus keep the earth clean; and in thousands of other kinds of work.

Now this tendency, commenced in microbian life, is continued and carried to a much higher degree in multicellular life. With the microbe the aim is to accomplish a single thing — to make alcohol, wine, beer, cider, or tear in pieces dead matter. In every case the aim is simply to do one thing. The workers therefore in every case are one species. The work is one, the colony is one, and every member of the colony helps do that one work.

But with the cell the plan in view is complex. The object is to build up many parts, — as the parts of a plant, or the organs of the animal, — with these parts so related to one another as to constitute a complete organism. As each part is different in form and texture from every other part, it requires a different kind of workers. There are therefore as many different colonies, or species of cells, as there are different parts in the organism to be built up and sustained. Each colony of cells, like the colony of microbes, is appointed to do a single kind of work. But each colony works also with the higher aim so to do its work, so to build and sustain its part, that it may be harmonious with, and helpful to, all the other parts of the complex organism. As an individual, the cell works, like the microbe. As a colony, the cell works with the higher object to make and support a body with parts complete. Microbes form

and work in single colonies which have no relation to one another; but cells form and work in many colonies, and these colonies all unite into one community and work together, like individuals, for a still higher purpose.

Along with this higher capacity for associative work is also developed in the cell a higher and more complex vital relation. In its primitive form the microbe seems to have little or no vital relations with its fellows. At all events, the only tie in this respect is between parent and child, and this is wholly prenatal. At the moment of birth the tie is broken. The child wanders away from parent and lives an independent life, caring nothing for parent, and parent caring nothing for child.

At a later stage in the evolution, when the colony is formed, the vital relation seems to be a little more pronounced. Especially is this the case when the individuals of the colony are glued together, all surrounded by a protecting membrane, and act as a single individual. But even here the relation is feeble. Separate one or more individuals from the colony, and they are not harmed by the separation, but under culture grow, multiply and form a new colony; while the parent colony is not harmed but mends itself and goes on as before.

Now, in many-celled life, whether vegetable or animal, the evolution of the vital relation is taken up exactly where it is left off by the microbe.

Vegetables of the lower orders may be cut in pieces, while each piece, so far from dying, may live, grow and reproduce its kind as perfect as the parent from which it is cut. Animals, likewise, of the lower orders, like the tape-worm, may be cut in pieces, and each part live and grow and become as perfect as the parent animal.

In these lower forms the vital relation is, at most, but a step in advance of that between microbes of the same colony. The parts are not dependent upon one another for life. They can live independently.

But with the advance to higher and higher forms of life the vital relation is more and more pronounced; the cells and the organs depend more and more upon one another. Finally, in the highest forms of life the vital relation becomes perfect. If any part is severed from the main body, that part perishes, and the main body is more or less injured. The well being of every part depends upon the well being of the whole; and the well being of the whole depends upon the well being of every part.

Examples best tell the story. Take the oak. The germ is the acorn. The life of this germ begins with a single cell. This cell is microscopic; it can be seen only through a powerful lens. It comes from a previous oak. As soon as born, it begins to grow, and soon divides into two cells. These two grow and divide into four. These four

into eight, and so on, until the germ proper, the nucleus of the forming acorn, becomes perfect.

Then the cells not only grow and multiply in all directions, but in multiplying they also differentiate into different species. These species are very different from one another, very numerous, and form each a distinct colony. They are all used to build and sustain the structure as a whole — some the meat, some the shell, others the husk. While each community, like a community of microbes, acts with the purpose to make and sustain a special part, all the communities work together with the higher purpose so to do each its work as to make all the parts fit one another and constitute a perfect acorn.

Now plant this acorn in the soil. It germinates and grows. One tendency is downward. A minute sprout pierces into the soil below. Cell after cell is added. They differentiate into many species. Each species is a colony to do a set kind of work. Some build the fiber of the tap root, others its pith, still others its bark. But they all work together in such relations to one another as to develop the tap root, as a whole, downward, and still downward, making it at length complete. Meanwhile, by the manufacture of thousands upon thousands of different colonies of cells, the main root divides into many smaller roots, these smaller roots subdivide into still smaller roots, and these into thousands upon thousands of rootlets. So

the work of division and subdivision goes on until millions upon millions of rootlets, as fine as fine needles, pierce the soil in all directions for a large distance around.

Thus is formed a complete network of roots and rootlets densely filling and occupying a large space of ground. The different species of cells composing them are numbered by the thousands,— perhaps by the millions. Each species form multitudes of colonies. Each colony, like a colony of microbes, supplies its own aid in its own way. Yet all the colonies are so related in their help to one another as to make the entire mass of roots and rootlets a firm and solid support to the full grown oak.

Meanwhile, the other tendency is upward. A tiny and tender little sprout peeps its little head through the soil, seeking the sunlight. A mighty work before it is to build the great oak? Every moment must glow with infinite courage and patience. But the tiny being is sufficient. Kissed by the sunlight, refreshed by the dews, and fanned by the breezes, cell after cell is added until, through days, years and centuries, the giant of the forest stands complete in stature.

In multiplying to do all this work, the cells differentiate into thousands of different species. Each of these species forms, like microbes, many colonies. All the multitude of colonies work, each in its own way,— some to build the bark of the trunk, others its sap, others its heart, others its

pith. At the top of the tall structure appear entirely new and different colonies to enable the trunk to divide into many lofty branches, these branches to subdivide into smaller branches, these into still smaller branches, and the division to continue until it ends all around in the finest twigs. Here appear another, entirely new and different set of species — some to build the buds, others the leaves, others the blossoms, and others the ripening acorns.

Here, at last, at the top of the tall trunk, is a dense network of branches and boughs, — a fit counterpart of the network of roots and rootlets at its base in the soil below. But the point of this part of the example above the ground, like that of the part below the ground, is to see that of all the millions of the different colonies of cells, while each one, like a colony of microbes, aims to serve a particular part, it also has the higher aim so to serve and adjust its part in its relations to all the other parts built and adjusted by all the other colonies, that all parts shall be harmonious and symmetrical in their proportions, and constitute a perfect oak.

In this way is built up every many-celled vegetable in the world. In every case the cell, like the microbe, works single-handed to a certain extent, but, at the same time, with the higher and loftier aim in view, so to do its single-handed work that, when done, it shall so unite with and fit all the other single-handed work wrought by all the other

cells of the complex organism as to make that organism complete in all its parts as a whole-handed work.

Here, too, is seen decided progress in the evolution of the vital relation. Every individual microbe in its colony enjoys a life peculiarly its own. It is independent. Apart from its fellows, it lives just as well. The individual cell, likewise, in the great oak enjoys a life peculiarly its own; but its life is also vitally related to the life of every other cell in the great organism.

Good to one cell is good to all. Food extracted by the leaves of the topmost boughs from air, rain and sunshine, finds its way down through and feeds alike all the cells of the branches, stem and roots, to the lowest rootlets. Conversely, food extracted from the soil by the lowest rootlets finds its way upward through, and feeds alike, all the cells of the root, stem and branches to the topmost boughs.

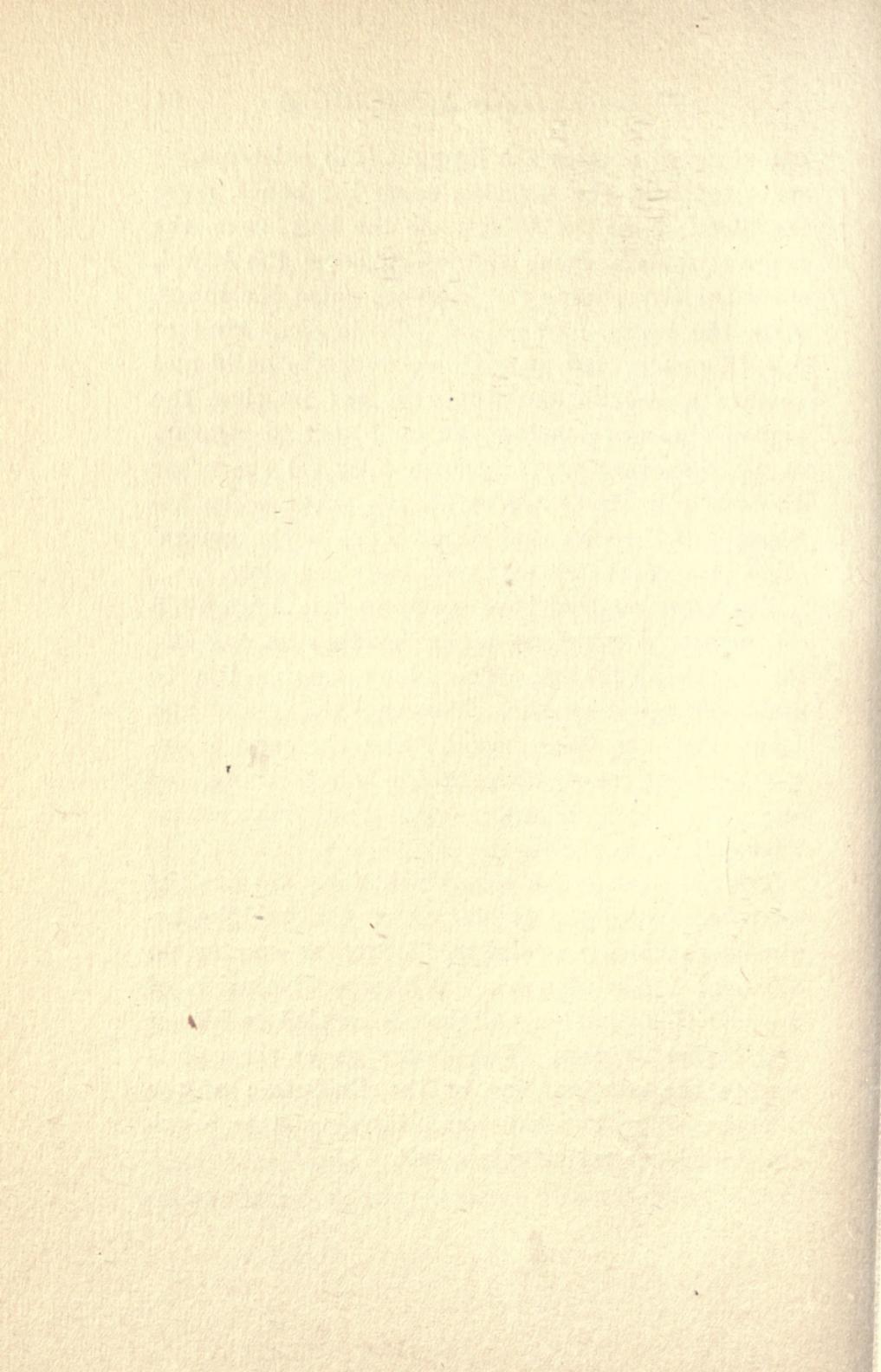
So injury to one cell is injury to all. Sever a part, as a limb, from the tree, and it soon dies, and leaves a wound to be healed on the parent stem. Cut the bark to the wood in a girdle round the stem, and all the cells from the lowest rootlets to the highest boughs feel the death stroke, and the whole tree dies.

So it is with the animal. The life of every human being, like the life of every vegetable, begins a single microscopic cell. This cell reproduces itself, and continues to multiply and differentiate until thousands upon thousands of differ-

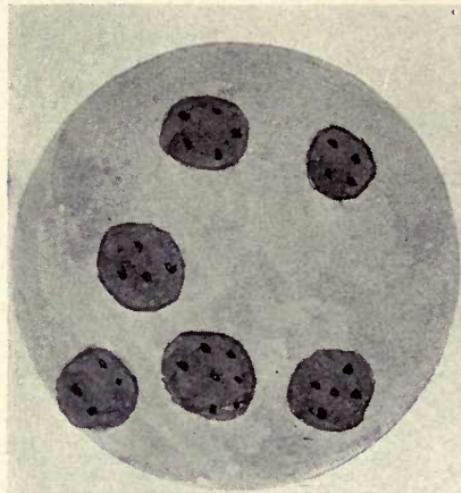
ent kinds of species are brought into existence,—some to build the muscles, some the bones, some the blood, some the skin, some the hair, some the nervous system, some the heart, some the bowel, some the liver, some the kidneys, some the lungs, some the brain, and so on. While each kind of cell, like each kind of microbe, works to build and sustain a certain part, it also has in view the higher aim so to fashion its own part in relation to all the other parts fashioned by all the other kinds of cells as to render all the parts, when finished, so suited to, and harmonious with, one another as to make the complex body complete.

The vital relation here seems to attain its highest point. A vital tie binds together as one life the entire organism. The blood carries life to every cell in the system. Puncture the skin at any point with the finest needle, and the pain is instantly telephoned through the whole being. If one cell suffer, all suffer with it; if one cell rejoice, all rejoice with it.

Thus the cell has a true Evolution. So has the microbe. With the Evolution of the microbe begins the division of labor. Different species do different kinds of work. With the Evolution of the cell this division of labor is carried to higher and higher degrees. The Evolution of the cell is simply the continuation of the Evolution of the microbe. The two are one. Every cell is a microbe. Every microbe is a cell.



BOOK SECOND
OUR INVISIBLE FRIENDS

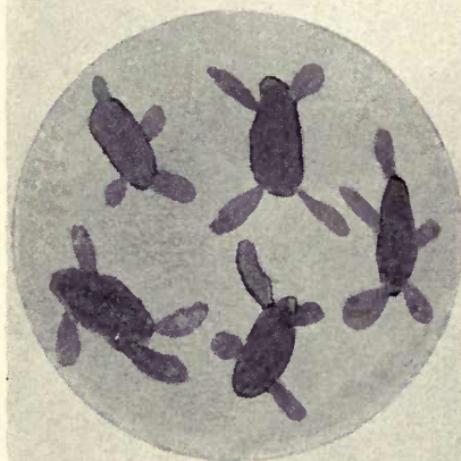


PRODUCTION of SPORES MICROBE of WINE

FIG. 50.



FIG. 51.



THE SAME BUDDING DEVELOPING SPORES

FIG. 52.

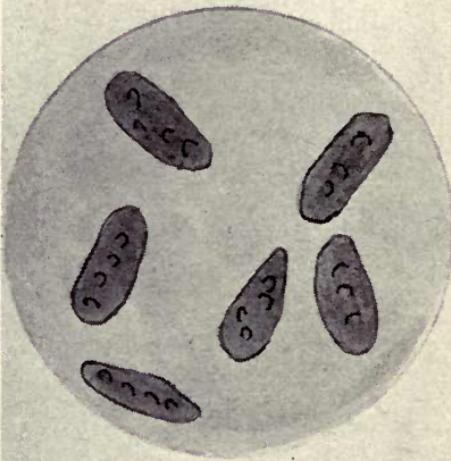


FIG. 53.

PART I

MICROBES OF ALCOHOLIC LIQUORS

CHAPTER XIX

THE MICROBE OF BEER

THIS microbe is a tiny being, spherical in form, and about eight micromillimeters in diameter,—a little over $\frac{1}{8000}$ of an inch. It would take 3,225 of them, placed side by side, to make one inch. Over 2,000,000 of them could be packed into the space occupied by a small drop of water.

Yet this tiny being has all the functions of common life. It eats, digests, excretes, moves, and, with great rapidity, propagates its kind. Its method of propagation is both by Budding and by the Production of Spores, as seen in Figs. 48, 49, and 50.

For all the good lager beer in the world, the world is indebted to this being. Without its aid no beer could be made. In the grain used in brewing beer there must be plenty of sugar. Only this microbe can convert the sugar into alcohol and carbon dioxide, two essential ingredients of beer. Any grain may be used, but the grain which contains the most sugar is the best. Barley contains

no sugar, and yet it is the best grain for making beer. The reason is because of all grains, barley contains the most starch, and a process has been discovered by which its starch is converted into sugar. By this means barley, of all grains, yields the most sugar; it is therefore the best for making beer.

The starch of the barley is converted into sugar by sprouting it. In sprouting, a principle is developed in the kernel called diastase. It is by the action of this substance that the starch of the kernels is transformed into sugar.

The grain for the purpose of sprouting is placed in cisterns filled with water sufficient to cover it. At a temperature of from 40 to 90 degrees the seed germinates. As soon as the sprouting begins, the diastase begins to be developed. The sprouting and the conversion take place simultaneously. To do the best work requires about eight days. The rule is to continue the sprouting until the sprout is about two thirds the length of the kernel. At this time the grain contains the greatest amount of sugar. When this point is reached, therefore, the skillful brewer stops the sprouting by taking the barley from the cistern and placing it in a kiln to dry.

The grain, after it is properly dried, is mashed or ground to powder. It is now called malt. In order to give a more desirable flavor to the beer, and to keep it better, a certain amount of hops is added to the malt. The composition is then

soaked in water until all its soluble parts are dissolved. The insoluble parts which remain in the liquor are now filtered out, and the clear liquid is called wort. This wort is sweet; it contains all the starch of the barley changed into sugar. It also contains the bitter principle extracted from the hops.

Now comes the critical point—to convert this wort into beer. For this purpose the brewer has on hand a beer yeast. This yeast is taken from the previous brewing. Every brewing produces two kinds of yeast. The scum is one kind, containing a certain species of microbes. The settling are another kind, containing a different species of microbes. The beer brewed from the scum is known as superior; that brewed from the settling is known as inferior. The brewer having on hand the desired kind, applies a sufficient amount to his wort, and thoroughly stirs it.

Every drop of this yeast contains millions upon millions of the tiny microbes. The sugar of the wort is the natural food of these beings. On it they begin to subsist, grow, thrive, and multiply with great rapidity, until they fill every drop of the wort completely.

The wort ferments and foams. But this fermenting process is wholly caused by the microbes. In subsisting on the sugar, by their life processes,—eating, digesting, excreting and multiplying,—they convert the sugar into alcohol and carbon dioxide. The alcohol, it need not be said, is the

stimulating quality of the beer; while the carbon dioxide affords the sparkling foaming quality.

When the sugar is nearly converted, the beer is put into casks, and sealed air tight. A proper amount of time is required for the final conversion of any remaining sugar, and for the "ripening." The beer is then ready for use.

By the process now described, or by some similar process, all the beer has been brewed which has been used in the world through all time. For every drop of it the world is indebted to this tiny invisible friend. This is saying a great deal for its services, because a great deal of beer has been consumed in the world. Beer was made by the Greeks four hundred years before the Christian era. The ancient Egyptians made it at a much earlier date. Since those times beer has been made, practically, all over the civilized world through all the centuries to the present day. But every drop of it was made possible only by the work of the microbe.

But not until 1895 did the microbe get any thanks. It had not been discovered. All through the centuries it had been doing its great service for the world, but the world knew it not. But in the year named two naturalists, one in France, the other in Germany, at the same time, turned their microscopes on some beer in process of brewing, and, lo! right under their eyes, saw the invisible beings busy at work. The problem was solved.

In those ancient days the first brewings must have produced only poor beer. Beer could now be made in this way, but it would be poor stuff.

But when the thoughtful brewer began to carry yeast from one brewing to another, the microbes were really under culture. As it were, they had been captured from the wilds of nature, and were being tamed and domesticated. By this culture they grew better and better themselves, and so did better and better work; until, to-day they have become so much improved that they give the world a choice article. But there is no reason why they may not, with more and better culture, do finer and better work, and so give the world a still better article.

CHAPTER XX

THE MICROBE OF WINE

WINE making, like beer making, dates back to very ancient times. In the Noachian myth, Noah gets drunk twice on wine. That was several thousand years before Christ. In the sacred books of the Brahmins and other oriental religions wine is frequently mentioned. This was several thousand years more ancient still.

From those remote days to the present wine has been produced in large quantities, practically all over the civilized world. In the United States, at the present time, about 75,000,000 gallons are used yearly. In older countries, pro rata population, much more is used. Properly used, wine is beneficial to the individual, and of great value to the world.

But for every drop which has been used, or will be used in the future, the world is, and must be, indebted to a certain species of microbes.

This invisible friend belongs in the same genus with the microbe of beer, but it is a different species. The form is different; in its mature state it is more elliptical, while its spores are oval. Like the microbe of beer, it propagates both by Budding and by the Production of Spores. In Fig. 51 ap-

pear individual adults; in Fig. 52, the same budding; in Fig. 53, the same producing spores.

This microbe is a trifle smaller than that of Beer; the adult is six micromillimeters in its longer diameter, and in its shorter diameter five. This means that its longer diameter is about $\frac{1}{4000}$ of an inch, and its shorter diameter $\frac{1}{5000}$ part of an inch. Accordingly a small drop of the wine has the capacity to contain 6,640,000 of these beings.

One may readily see how this microbe plays its part in wine making. Everybody knows that wine may be made from any one of all the small fruits; but that which is generally used, and is no doubt the best, is the grape. The berry is allowed to become fully ripe before harvesting, because it then contains the most sugar, and affords the richest flavor for the wine.

After gathering the grapes from the vines, in order to separate the juice from the pulp, they are put through either the centrifugal machine or the wine press. In either case the juice is at once conducted into the wine vat, where it is ready for fermentation.

This fermenting process converts the juice into wine; but it is caused wholly by the microbe. Investigation has shown the ripe berries on the vines contain on their skins great numbers of the spores of this microbe. In separating the juice from the pulp, these spores find their way into the juice in the vat. Here they quickly grow into the ma-

ture microbe. They then multiply with great rapidity by Budding and occupy every drop of the liquid. In subsisting on the sugar of the grapes, by their life processes the microbes convert this sugar into alcohol and carbon dioxide. This is the fermenting process, and is caused alone by the microbe. To complete it, with the liquid at a temperature of 60 degrees, requires about ten days. The wine is then clarified and put into casks or bottled. In either case, it is sealed air tight. After a proper length of time for ripening, the wine is fit for use.

Evidently this microbe, like the microbe of beer, only in a different way, has been for many generations in a state of culture. Originally, when men first began to make wine, this microbe must have been wild, and have come into the grape juice from the atmosphere. But as the industry increased and became general, the microbes would inhabit more and more the vineyards. Their spores are found not only on the ripe berries but also on the leaves and vines. The leaves fall, and the spores live in the soil until the next season. Then, in cultivating the soil, they rise on particles of dust, and thus find their way again to the leaves of the vines and the ripening berries. With this process continued from year to year, it must afford, in some degree, culture. The more culture, the better the work done, and the more choice become the qualities of the wine.

CHAPTER XXI

THE MICROBE OF CIDER

NEARLY every farmer has more or less orchard, and makes more or less cider every year. Allowing that, in the United States, only one barrel of cider is yearly made to every hundred acres of land cultivated, the yield would be 220,160,000 gallons. The real product is no doubt more than twice this amount. In older countries, where the farms are smaller, the product, *pro rata* the acreage cultivated, is probably much greater.

But, as in the case of beer and wine, for all the cider manufactured in the world the world is indebted to a certain species of microbes.

Everybody knows that cider is made from the apple. The perfect apple consists of three well defined parts. First, the core divided into five cavities containing the seeds. Second, the fleshy or edible part consisting of minute cells filled with juice. Third, the skin surrounding and protecting the other portions. It is of course the juice of the cells which is transformed by the microbe into cider.

Ten bushels of apples will make one barrel of cider. The apples should become thoroughly ripe on the trees before gathered; they then contain the

most sugar, and will give to the cider the best flavor. When gathered, the apples are ground and pressed. The juice is thus separated from the pulp, and is called new cider.

The new cider is now put into barrels. The bung of each barrel is left open. At a temperature of about 60 degrees the cider in forty-eight hours will begin to work or ferment. This fermenting process is the work of the microbe, and of the microbe only. Innumerable spores of the microbe are on the apples, and find their way into the new cider. Other spores or microbes of the same species come in from the atmosphere. They all subsist on the sugar of the new cider, thrive, grow, multiply rapidly, and occupy every drop of the liquid. As in the case of wine and beer, the microbes by their life processes convert the sugar into alcohol and carbon dioxide. This causes the fermentation.

As the cider works, it will foam, and more or less will run over from the bung. Keep the barrel full with other new cider. For this purpose use not a drop of water — only cider. The fermenting process will continue some weeks, perhaps months. When it ceases, and the cider becomes quiet, the work of the microbe is done; the sugar is all converted.

Now rack off the cider. Rinse thoroughly the barrel. Put the cider back into the barrel. Bung airtight. Thus preserved, the cider will keep a long time, and grow better with age.

Old cider is decidedly anti-bilious. A person troubled with biliousness will be benefited by taking a glass with each meal.

Old cider is also the natural remedy for jaundice. The acid is really the antitoxine for this disease. As soon as taken, drink from one to two quarts of cider every day. It is the best, if not the only, cure in the world.

One thing more: Out of new cider may be made a beautiful cider wine. Get pure new cider. If you buy it of a peddler, it may be adulterated with water. Take a barrel,—32 gallons,—of the pure apple juice. Let it work one week. Then rack it off. Rinse the barrel. As you put the cider back into the barrel, mix with it forty-five pounds of sugar and three dozen eggs well beaten. The mixture will work powerfully. Keep the barrel full with new cider—not a drop of water. It will work about four months. When it becomes quiet, draw it off again. Rinse the barrel. Put the wine back into the barrel, and bung airtight. It will keep indefinitely, and grow better with age.

Here you have a home-made, delicious and sparkling wine, containing about twenty per cent. of alcohol. Taken in small quantities with meals, it is appetizing and wholesome.

CHAPTER XXII

THE MICROBE OF ALCOHOL

ALCOHOL is a colorless transparent fluid. It boils at 175 degrees, while water boils at 212 degrees. It burns with a bluish, almost invisible flame, intensely hot, and without smoke. It is exceedingly volatile; exposed to the air, it evaporates rapidly. Alcohol has a great avidity for water, is agreeable to the taste, and has a fruit smell. It is also one of the best antiseptics.

With so many good properties, alcohol does great and good service for the world. It makes one of the best heating lamps for the dentist, drug-gist and jeweler. It is largely used in all the museums of the world, to preserve specimens in natural history. As a powerful solvent, it is extensively used in making varnishes and compounding medicines. A thousand perfumes with their delicate aromas, and cordials to endless extent, owe to alcohol their very existence. As a remedial agent, alcohol is employed in one form or another by nearly every physician in the world. More than all, on alcohol depends the existence of all malt and distilled liquors the world over.

The consumption therefore of alcohol is enormous. Its manufacture forms one of the great staple industries of the world, and becomes the

source of fabulous wealth to individuals, states and nations. With one sudden blow, strike alcohol, in its every form, from the entire world, so that not a vestige of it shall anywhere be longer in use, and what a void! Thousands upon thousands of manufacturers and dealers the world over collapse. Millions upon millions of laborers are thrown out of employment, with their families crying for bread. Such a financial panic follows in the wake as the world has never seen. The whole world feels the terrific shock, like the city at the mercy of the earthquake. And the hand on the dial of time turns back twenty-five centuries.

Wonderful it is to think that all this great service is rendered to the world by an invisible being so small that millions of its kind may float in a drop of water, with plenty of elbow room. But such is the fact. Spurious alcohol may be made by the mixing of chemicals; genuine alcohol by the microbe only.

All fermentation is caused by some kind of microbe. By every form of fermentation, too, where the materials fermented contain sugar, alcohol is produced. All the different kinds of microbes, therefore, which produce fermentation where the materials used contain sugar, may be employed to produce alcohol. These materials include nearly all kinds of grain, fruit, berries, and some vegetables.

Whatever raw materials are used, they must first be subjected to the fermenting process by the mi-

crobe. A beer yeast is generally used to inoculate the mixture. It will secure quicker and more vigorous fermentation. When the fermentation ceases, the work of the microbe is done; the sugar of the materials is all converted into alcohol and carbon dioxide. We now want only the alcohol. The wort, after it is strained, may contain ten per cent; the rest, ninety per cent, is water.

The problem now is, to separate the water,—or at least a large portion of it,—from the alcohol. This is done by distillation. In Fig. 54 is shown just enough of the apparatus to explain the principle. It consists of a retort, a, set in furnace, b, the condenser, c, the receiver, d, and the pipe or worm, e, reaching from the retort over, and down into, and through, the condenser to the receiver.

Fill the condenser with cold water and ice. Fill the retort,—one hundred gallons,—with the liquor to be distilled. Ten gallons of it are alcohol; ninety, water. Under the retort kindle the fire in the furnace. Heat the liquor to 175 degrees; no more. At this temperature the alcohol boils and passes into steam, but the water does not. To boil and convert the water into steam requires a temperature of 212 degrees. Keep the temperature in the retort, therefore, steadily at 175 degrees. The alcohol passes into vapor. The vapor rises into the pipe. The water remains behind. This is what you want—the separation of the alcohol from the water. This is distillation. In due time, all the alcohol in the retort—ten gallons

— passes into vapor, finds its way through the condenser, and enters the receiver as liquid.

But this is not all. The alcohol has strong af-

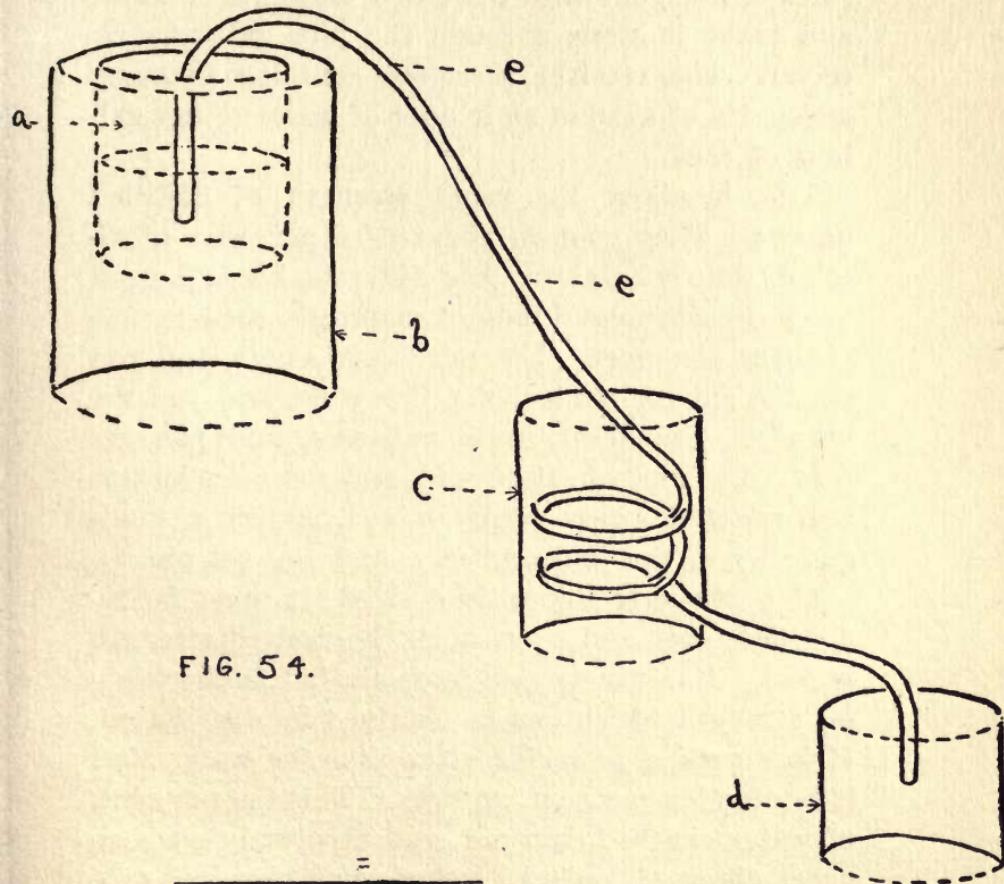


FIG. 54.

finity for the water. Its molecules have a powerful attraction for the molecules of the water. Besides, its molecules are the same when in vapor as they are when in liquid. Each one is composed of four atoms of carbon, six of hydrogen, and two of oxy-

gen, $C_2H_6O_2$ — firmly locked together. When rising into steam, they are not broken up, but remain the same. And each and every one of these molecules of alcohol clings tight to a molecule of water and takes it along through the pipe into the receiver. The receiver therefore contains as many molecules of alcohol as it does of water — ten gallons of each.

This is about the usual strength of distilled liquors. They contain about fifty per cent. of alcohol, the rest water. The different kinds depend upon the different kinds of materials used in fermenting the wort. Use pure cane sugar, and you get the spirits of alcohol. Use wine, and you get brandy. Use West India molasses, and you get rum. Use rye, wheat or corn, and you get whiskey. Use rye and wheat evenly mixed, adding a small quantity of the juniper berry, and you get gin.

If a stronger liquor is desired, it must be redistilled, over and over, until the desired strength is had. But ninety per cent. alcohol is the highest strength which can be obtained by distillation. It has such a powerful attraction for water that it retains ten per cent. anyway. This ten per cent. of water can be taken out, and absolutely pure alcohol obtained, only by using some chemical substance, like chloride of calcium, which has a more powerful attraction for water than for alcohol.

Absolute alcohol freezes at 140 degrees below zero; while mercury freezes at 40 degrees below zero. Therefore for the lower temperatures alcohol is used in making thermometers.

MICROBE of BREAD

MULTIPLYING.

SPORES.

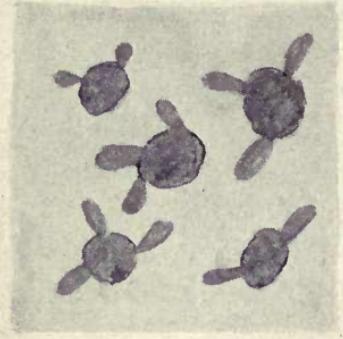
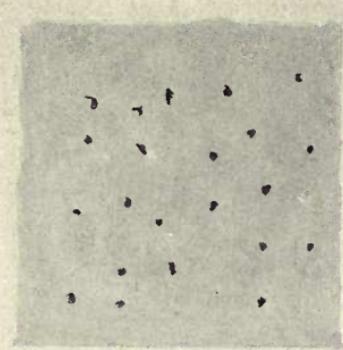
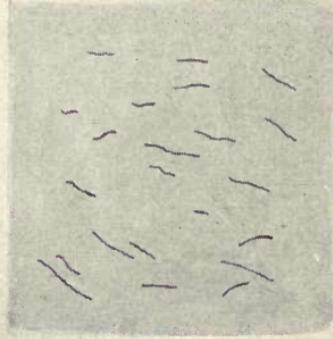


FIG. 55.

FIG. 56.

FIG. 57.



WILD ANCESTOR.
FIG. 58.

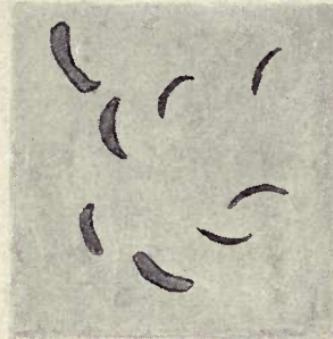


FIG. 59.

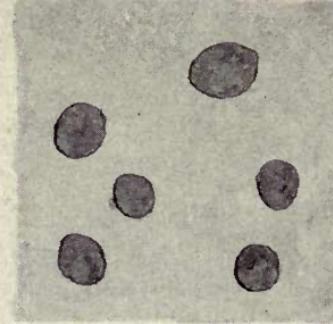


FIG. 60.

PART II

MICROBES OF THE HOME

CHAPTER XXIII

THE MICROBE OF BREAD

CERTAIN species of microbes render good service, the world over, in the home. This service is essential. In the present state of civilization, no home can be well furnished without it.

One of these is the microbe of bread. It is represented in Fig. 55. It multiplies by Budding, as seen in Fig. 56.

Now, mix flour with water, or with milk, or with both water and milk, into dough. Bake it immediately. Or, let it stand a while, and then bake it. In either case the result will be the same,—a hard, indigestible loaf, unfit for any human stomach.

But before mixing, as before, put into the water, milk, or both water and milk, as the case may be, a proper amount of baker's yeast. Let the dough stand a proper length of time at a temperature of eighty degrees. Then bake it. The bread is light, agreeable to the taste, nourishing and wholesome.

In the former case the particles of the dough are packed solidly together and baked in that condition, with nothing to push them apart. The bread is therefore solid. It could not be otherwise.

In the latter case the yeast introduced is literally full of living microbes. Their services make the bread light. As soon as these beings find themselves in the dough, they begin to subsist on the sugar of the flour, and grow, and multiply with great rapidity, until they occupy every part of the dough. In consuming the sugar of the dough, they decompose and digest it. The decomposition products are carbon dioxide gas and alcohol. The entire mass of dough is thus saturated with this gas and alcohol. The gas is expansive, and, by its force, pushes apart all the particles of the dough, leaving interspaces between them. As the dough thus occupies more room, it is said to "rise." The rising is nothing more or less than the separating one from another all the particles of the dough, thus expanding it into a larger volume. This is what renders the bread light and spongy,—all owing to the friendly work of the microbes.

A great service this to the entire world. All the bread used in every home, which is made light, palatable and nourishing by using baker's yeast, is the gift of the microbe. This being conferring such infinite good is yet but about the $\frac{1}{4000}$ part of an inch in diameter. This means that the yeast is wet, that the microbe is full grown, Fig. 55, and

that it takes about 4,000,000 of them to fill the space occupied by a small drop of water.

Yeast, in its dry form, is alive with the same microbes in their sporadic state, — Fig. 57. These spores are about the $\frac{1}{800}$ part of an inch in diameter. This means that it requires about 32,000,000 of them to fill the space of the small drop. But they do equally as good work as the microbes of the wet yeast. As soon as the dry yeast is dissolved in tepid water or milk, and introduced into the dough, the spores increase in size until they are fully grown; then they work exactly as do the microbes of the wet yeast.

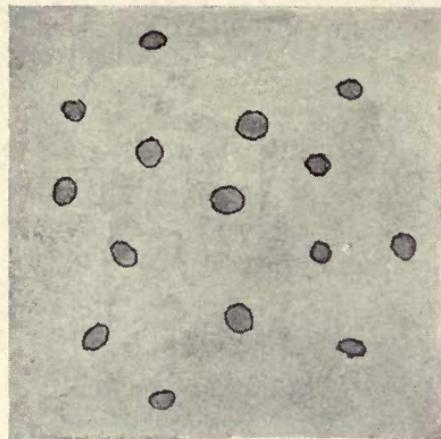
Wet yeast will not keep long. It is therefore conveniently used in cities and villages, where it can be daily obtained in fresh condition. Dry yeast will keep almost indefinitely. Therefore it is more suitable for use in rural districts, where daily supply is impracticable.

One may notice that the microbe of bread closely resembles the microbe of beer. There is a natural cause for this. The two originally, in their wild state, are the same. The wild ancestor from which both these microbes have been derived, is thread-like in form, as represented in Fig. 58. By a process of domestication and culture through many generations, the brewer has changed the ancestor into the oval form, Fig. 59. By a process of culture along another line, probably for as long a time, the baker has changed the ancestor into the spherical form, Fig. 60.

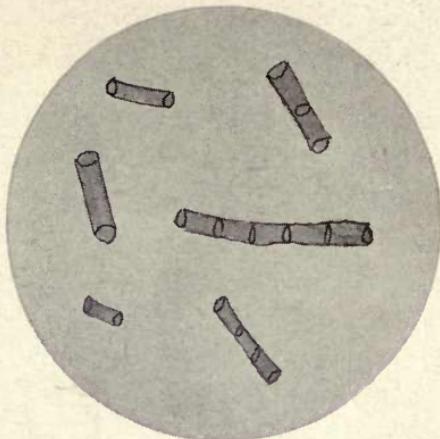
This process of selective culture on divergent lines from the same ancestor is paralleled in thousands of instances in the higher forms of vegetable and animal life. Take a single example:

The modern dray horse and the trotter have both descended from the same wild ancestor. By selective breeding, and culture along one line, has come the heavy weight horse for hauling heavy loads. By selective breeding, and culture along a different line, has come the light weight horse for speed. It takes about two and a half trotters to make in weight one dray. Each, in a poor way, may do the other's work; but each can do the work, for which it has so long been trained, a thousand times better.

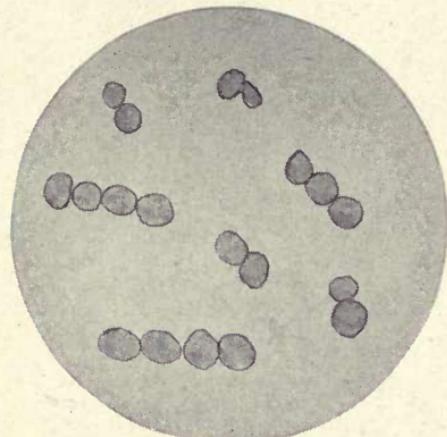
The parallel is most complete. The microbe of beer and the microbe of bread, coming from the same wild ancestor, now differ one from the other, in their tame and domesticated state, quite as much as the dray differs from the trotter. The beer microbe is almost exactly two and a half times as large as the bread microbe. The beer microbe can also do the work of the bread microbe: that is, the baker can bake his bread with the brewer's yeast. And the microbe of bread can do the work of the microbe of beer; that is, the brewer can brew his beer by using the baker's yeast. But the result in either case is quite as unsatisfactory as it is when the dray and the trotter exchange their work. Each microbe does its best only when used on that line of work for which it has so long been trained.



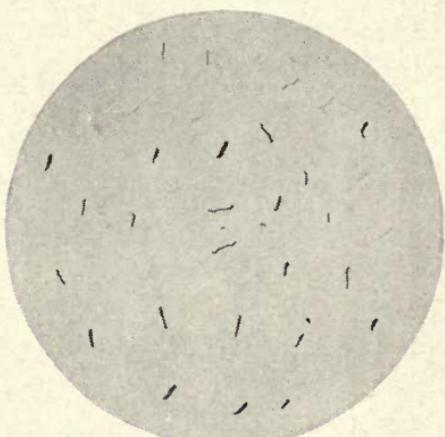
MICROBE of MILK FIG. 61.



MICROBE of VINEGAR FIG. 62.



MICROBE of INFLUENSA FIG. 70



MICROBE of GRIPPE FIG. 71

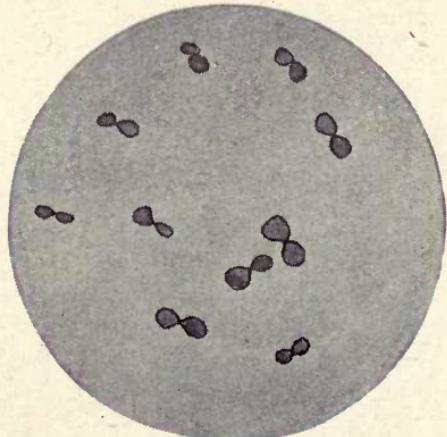
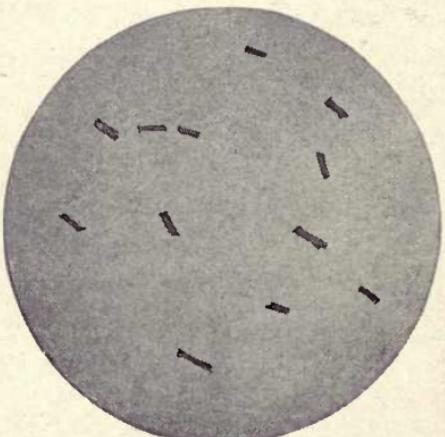


FIG. 73.



MICROBE of LOCKJAW FIG. 74.

MICROBE OF WHOOPING COUGH

Facing Page 85

CHAPTER XXIV

THE MICROBE OF MILK

MILK, fresh from the cow, after standing a few hours in warm weather, as every one knows, becomes sour. The cause of the souring is not in the milk itself. Milk taken from the cow and sealed airtight, without coming in contact with the air, will not sour. This proves that the cause of souring is not in the milk itself.

Therefore the something which sours the milk must be either the air, with which the milk comes in contact, or that which comes out of the air into the milk. But it is not the air. Fill a small glass jar with sweet milk. Leave out the cork. Set this jar in a larger glass jar. Seal airtight the larger jar. Now set the larger jar in a vessel of water on the stove. Boil the water for some time. This sterilizes the air in the larger jar and the milk, too. The sterilized air within the larger jar comes in contact with the sterilized milk in the smaller jar. But the milk will never sour. This shows that it is not the air which sours the milk, but something within the air which comes from the air into the milk.

This something is now well known to be the microbe represented in Fig. 61. It resembles the mi-

crobe of bread, but is much smaller. The air is thickly populated with this species of microbes. They as naturally like milk as pigs clover. As soon as the milk comes from the cow, they are attracted into it in great numbers. As soon as there, too, they begin to grow and multiply with great rapidity. One may become 3,000 in six hours. At this rate, in the same time, a thousand become 3,000,000, and a million become 3,000,000,000.

Coming into the milk so rapidly, and, at the same time, multiplying so rapidly, the milk soon becomes densely populated. By the time the milk-man's milk gets to one's table, especially in warm weather, a common glass of it will probably contain not less than 50,000,000 of these beings.

These microbes are the cause, and the only cause, of all souring of milk. As soon as in the milk, they subsist on the sugar of the milk, and, by their life processes, convert this sugar into lactic acid; and this acid is the essential element of all sour milk.

It is true that a number of different species of microbes may, by converting its sugar into lactic acid, sour milk. But ordinarily, and almost always, only one species is the active cause. Hence, this species has been called "*bacillus acidi aceti*." But the plain English name, microbe of milk, is good enough for the present purpose.

It is true that a number of other species occasionally find their way from the air into the milk, but only to do it harm. While they cause

the milk to some extent to sour, they work not a little mischief. Some cause the milk to curdle, make it ropy, or even taint it. Others give the milk different hues of color, of blue, red or yellow. They have no business to meddle with the milk — enemies to the milkman, pure and simple.

The milkman has two means of successfully avoiding these pests. First, cleanliness. Keep the cows clean. Keep clean the stable. Keep clean the milk cans and other utensils. Second, as soon as the milk is taken from the cow, reduce it to a low temperature, and keep it there until used.

The microbe that simply causes the milk to sour, without any attendant mischief, is the real friend. True, the early souring of the milk may be troublesome to the milkman. But he has an easy remedy. He should Pasteurize the milk; that is, before distribution, heat the milk to 165 degrees. This destroys all the germs in the milk which sour it. The milk will then keep sweet practically long enough.

The milk, before used by the customer, should be Pasteurized anyway. After it comes from the cow, several hours usually intervene before it reaches the customer. By this time every glass of it, as we have said, contains millions upon millions of germs. To the adult, or persons in vigorous health, these germs are harmless. But to invalids and young children it is not safe. If, therefore, the milkman Pasteurizes his milk just before distri-

bution to the consumer, all danger is avoided. If he does not, as soon as the milk is received in the home, it should there be heated to 165 degrees, bottled, corked with sterilized cotton, and kept in a cool place. It will then keep sweet for a long time, and its use will be safe and wholesome.

The natural process of souring milk is a decided benefit. It separates the milk into its four elements, and enables the owner to use each part to best advantage. Every hundred quarts of milk contain eighty quarts of water, five of cheese, four of sugar, and three of butter. The microbes consume the sugar and convert it into lactic acid. The acid unites with the water, and thus precipitates the cheesy element, while the butter rises to the surface in the shape of cream. The cream is converted into butter, while all the other parts are used as feed for calves, swine, and so on.

It need not be said that the separator now usually takes the place of the microbes, separating the cream from the milk as soon as it comes from the cow. But the practical result in each case is the same.

Every one is naturally interested in milk. There is a time in every one's life when he lives wholly on milk. It is the natural food for all young children. It is their best, if not their only, food. It is the natural and only food of all the young of the lower mammals as well. Milk contains more nourishing properties than any other kind of food. The young, therefore, of all mammals, including

man, become fat and plump. It is because they feed on the richest and best food in the world.

Hence the production of milk is one of the great industries of the world. The United States keeps about 20,000,000 cows,—one cow to every four persons. At the rate of eight quarts of milk per cow per day, the entire flow of milk would be equal to a river of milk six feet deep, twenty-four feet wide, and flowing perpetually at the rate of 240 feet every 24 hours. This river of milk in one way or another, including butter and cheese, constitutes, in some respects, the best and most essential part of the food of more than 90,000,000 people.

Surely the microbe of milk figures in human life on a large scale.

CHAPTER XXV

THE MICROBE OF BUTTER

THE up-to-date dairyman separates the cream from his milk with a machine. This is done as soon as the milk comes from the cow. If this cream is churned immediately, while it is sweet, the butter will be unsavory. No person in the world,—with a few possible exceptions,—will like it or want it.

Hence the dairyman, before churning, allows the cream to stand until it “ripens.” This may require twelve, twenty-four, or more hours, according to circumstances. The cream ripens sooner at a temperature of 65 or 70 degrees than at lower temperatures. Other conditions may vary the time. But if the dairyman churns the cream the moment it is ripe, the churning will be easy, and the butter will have the best flavor possible.

Now microbes, especially two species, are the sole cause of ripening. As the milk is new and sweet when the cream is separated from it, the cream takes along within itself a large quantity of the microbes of milk. These now subsist on the sugar of milk, which the cream also takes along, and converts it into lactic acid. This sours the cream. The other species, which are the microbes

of butter proper, subsist on other qualities of the cream, and convert them into substances which give to the butter its fine flavor and aroma.

Without the aid of these two species of microbes there could be no good or fine flavored butter in the world. Precious, indeed, are their services.

Therefore these two species have been isolated and formed each into a pure culture. These cultures have been formed into two yeasts. These yeasts have already been largely used in Europe with fine success. They are now beginning to be used in this country. There is no reason why their use may not, in the near future, become universal.

Of course, without the aid of these yeasts,—simply letting nature take its course,—a fairly good butter had been made during an indefinite time in the past. Without their aid, too, an equally good butter might supply the market during an indefinite time to come.

Yet every dairyman knows that, without the use of these yeasts, failures have occasionally occurred in all past time. It is certain that without their use failures will at times occur in the future.

But from experience already had, it is certain that, with the use of these yeasts, such failures may be reduced to a minimum, if not quite eliminated. Certain that, with their use, a higher and finer grade of butter may be made, with nearly, if not quite, uniform success.

The process is easy and simple. As soon as the milk comes from the cows, let the separator do its

work. Then, into the cream thus obtained, immediately put both the milk yeast and the butter yeast. Stir well. The cream must now stand until thoroughly ripe. If churned too soon, the butter will not be first-class. This is because the microbes have not completed their best work. If churned too late, the butter will be even worse. This is because the proper microbes have not only completed their work, but other and improper microbes have come into, and taken possession of, the cream, lived on certain of its ingredients, and by their life processes have generated taint for the butter. But, if the cream is churned at exactly the right moment, the butter will be at its best.

If, at this moment, we could look into the cream with microscopic eyes, we should see almost an infinite number of minute globules. They are the globules of butter. They are held together by a gluey substance of the cream. The cream is sour, or ripe, and therefore in just the right condition for the globules to be separated. Set the churn to whirling. Its centrifugal motion whirls these globules together. They soon all adhere in a compact mass. Now draw off the buttermilk. Prepare the butter for the table. The work is complete.

Under this treatment success will come nearly every time and uniformly. Still, even then, there is the mere possibility of failure at some time. If it occurs at all, it is more likely to come during

the hot days of July or August. Some days then are not only the hottest in the year, but the atmosphere, at the same time, has the highest degree of humidity. These conditions are most favorable to the growth of the species of microbes in the atmosphere which are enemies to the dairyman. They multiply rapidly, and populate the air with more than their usual numbers. Consequently more of them than usual find their way into the new milk and cream. By their life processes these enemies succeed in generating substances which spoil the gilt edge of the butter.

But for this there is a natural remedy. During the months of July and August, immediately the cream is separated from the milk, heat it to 165 or 170 degrees. This sterilizes the cream. All the germs, good and bad, are destroyed. Now at once put into the cream the yeast of milk and the yeast of butter. Stir well. The millions upon millions of the right microbes in the yeasts quickly grow, multiply, take possession of the entire cream. They get the start of all enemies. Their work is sure. The butter is first-class. Failure is impossible.

A present survey of the situation leads one to expect that, at a not very distant day in the future, this heating process, together with the use of the two yeasts, will be universally adopted by creameries, and also by private dairies, — and this not only for July and August, but for every day in the year. No brewer thinks of brewing beer without using

beer yeast. No baker thinks of baking bread without using bread yeast. So, the time is coming when no dairyman will think of making butter without using butter yeasts, with the cream sterilized. We may then hope for a uniform higher grade of butter. Success will be every time sure. Failure impossible.

At least, if failure comes, the fault will not be in the butter maker but in the yeast. No brewer can brew good beer with poor yeast. No baker can bake good bread with poor yeast. So with poor yeast no buttermaker can make good butter. The yeast must be perfect. Then, and then only, will the butter be perfect.

The crucial point, therefore, turns on the manufacture of the yeast. Only the expert will do for this. He must have a keen intellect united with a conscience which turns neither to the right nor the left. He must put intellect and conscience into every part of his work. He must be educated and have experience. He must understand his business. He must know all that is known about microbes. He must know how to isolate the right species. He must know how to form of these pure cultures. Especially must he know how to make of these cultures gilt edge yeasts. With these yeasts the skillful buttermaker will make only gilt edge butter. The consumer will be happy.

CHAPTER XXVI

THE MICROBE OF CHEESE

MAKING cheese consists of three distinct parts. First, separating the caseine, or the cheese part, from the other parts of the milk. Second, pressing the cheese. Third, ripening the cheese.

The first step, considered in itself alone, is purely a chemical change. Microbes have nothing to do with it. Chemical analysis of milk shows it is composed of about eighty-seven per cent. of water, four and seven-tenths per cent. of sugar, three and six-tenths per cent. of butter, three and three-tenths per cent. of caseine, seven-tenths of one per cent. of albumen, the same amount of ash, and a certain amount of free alkali.

The chemical principle introduced to cause the separation of the caseine from other parts of the milk is rennet. This rennet is simply the stomach of the unweaned calf preserved and kept in its dry form for this purpose.

As soon as the milk comes from the cows, it is placed in a tank and the rennet applied. The chemical change takes place best with the milk at a temperature of 110 degrees. A piece of rennet, corresponding in size to the amount of milk, is dissolved in warm water, and the solution poured

into the milk. The milk is well stirred. Then it is kept quiet for the chemical change to take place.

This change consists of two parts. The caseine is distributed all through the milk in exceedingly minute particles. As soon as the rennet is introduced, it finds its way through all the milk to each and every one of these particles. The moment the particle of rennet comes in contact with the particle of caseine, it acts chemically upon that particle by splitting it into two parts. These parts are called proteids. The one proteid is held only in semi-solution, and is easily precipitated. The other is held in closer solution, and is not precipitated at all. But it is so small that it is of little or no account to the cheese-maker, while he saves it in the whey.

This completes the first part of the chemical change. The work of the rennet is at an end. But the caseine is not precipitated. The milk is not curdled. Each and every particle of caseine is still chained in semi-solution by the free alkali. Happily the ash of the milk contains several salts. One of these is the salts of calcium. The moment this is set free, it acts chemically upon the free alkali, neutralizing it. The chain that held in semi-solution each and every particle of caseine is thus broken. All the caseine is precipitated. The milk is curdled. Both parts of the chemical change are complete. The milk is changed into curd and whey. With itself the caseine has taken along the bulk of the butter, sugar and albumen.

The first step in making the cheese is thus complete. The second step is purely mechanical. It consists in pressing the cheese. The whey is drawn off from the curd. The curd is then prepared for the press. When ready, it is placed in the cheese hoop, and the hoop is adjusted in the press. Sufficient power is applied long enough to press all the particles of the curd closely together, so that they will firmly adhere in one mass.

The third step consists in ripening the cheese. To say that this is the most important step would perhaps be not quite right, because each of the three is all-important. By omitting any one, no cheese could be made. But the final step is here emphasized because it is wholly the work of microbes. Their work alone gives the cheese its fine flavor, makes it easy to digest, and wholesome.

As soon as the cheese is taken from the press, it is suitably prepared and put in its right place in the ripening room. Here it should remain until the microbes do their complete work, and the cheese is thoroughly ripe. Many of these microbes come from the milk and along with the curd, and are already in the cheese. Many more come into the cheese from the atmosphere. They all gradually multiply until they occupy in great numbers every part of the cheese. Scientists have estimated that every gram of the cheese, when in its fully ripening process, contains from 880,000 to 5,600,000 microbes. This means that each pound of the cheese then contains from 400,000,000 to 2,680,-

000,000 microbes. The cheese is thus literally filled with these living beings. The entire mass, like so many honey bees, are actively at work, and do a vitally good thing for the cheese. They grow, multiply, and live on certain properties of the cheese. In other words, they consume these properties as food. Meanwhile, during their life processes, they secrete certain substances which give to the cheese its fine flavor, render it brittle, easily digested, and make it an excellent article of food.

But they work slow. It takes time. The medium in which they work is a solid. It takes longer than it would to do a similar work in a liquid. This is only natural. The softer the substance the quicker it is worked. The wooden house is built quicker than the stone house. The expense of polishing a certain royal diamond was \$40,000. Its hardness required costly machinery, the highest skill in workmen, and long time. So our infinitely little mechanics require time according to the medium in which they work. In the liquid cream their work may require but a day or less. In the more solid cheese, it may require months. An expert cheese-maker told me the other day that it takes at least six months properly to ripen a cheese.

Here's the critical point — time. In so far as I know, cheese-makers rush their cheese to market before it is half ripe. It is curdy. It lacks the fine flavors. Gentlemen of the dairy, hold on! You grasp your money too soon. Wait. It will

pay you. "Haste makes waste." The green baldwin is unfit to eat. Your green cheese is an imposition upon the consumer. Put it not upon the table until it is ripe. Let your invisible friends put in their best work. It will give you the best results. The last strokes of the polishing machine bring out the finest qualities of the diamond. The final work of the microbes brings out the best qualities of the cheese. Let them do it. It will please the public. Your bank account will then be at its best.

Still, at its best, mishaps may come. Occasionally the ripe cheese may be unsavory. What's the matter? The same thing which sometimes happens in butter-making. With certain atmospheric conditions greater numbers of microbes are generated which are enemies to the cheese-maker. They come into the milk in greater numbers. In the cheese they do more to control its ripening. In their life processes they generate certain acids which give to the cheese its unwelcome taste.

At times, too, though less frequent, the cheese may be decidedly poisonous. It gives sickness to the consumer, and some fatalities.

For all such mishaps, in the present state of knowledge, there seems to be one remedy, and one only. Isolate the true cheese microbe. It is easily done. With it make a pure culture. With the culture make a true cheese yeast. Keep this yeast on hand. As soon as the milk comes from the cows heat it to 165 degrees. This kills all bad mi-

crobes. The instant the milk cools to 110 degrees, insert the yeast. The true cheese microbes in the yeast will soon grow, multiply and take possession of the entire milk. Then introduce the rennet. Stir well. As the milk curdles, great numbers of these right microbes come along in the curd. As the cheese comes from the press, they are already in it. They keep out all intruders. In the ripening process, they do the entire work. When thoroughly ripe, the cheese is most excellent in quality, and always absolutely wholesome.

Meanwhile, until this yeast is forthcoming, as in butter-making, so in cheese-making, absolute cleanliness and prompt action at every point in the process, must be the safeguards. This will give the best results and reduce all danger to its minimum.

CHAPTER XXVII

THE MICROBE OF VINEGAR

THIS microbe is represented in Fig. 62. In form it is cylindrical, and it appears in single cells, filaments and chaplets. The longer diameter is from one and a half to three micromillimeters; its shorter diameter is about one half this length. This means that many hundred millions of these beings could find plenty of room in a small drop of water. But they cannot live in water. They are aerobic, that is, air-breathing; and can live only in the air.

All the genuine vinegar in the world is made through the agency of this microbe. Spurious vinegar may be made of chemicals; the genuine only by this living being. The true process consists in converting the alcohol of some liquor into acetic acid. Any one of many kinds of liquor may be used for this purpose. The essential requisite is that the liquor used shall,—by having been made by the fermentation of certain materials,—contain from four to ten per cent. of alcohol. Cider is the best. It contains about eight per cent. of alcohol. By one set of microbes the apple juice is converted into cider; by another set the cider is converted into vinegar.

The process of this conversion is simple and quickly told. The essential quality of vinegar is acetic acid. It is this acid which gives vinegar its sharp taste. But the essential quality of cider is its alcohol. Now the making the cider into vinegar is simply turning the alcohol into the acid. This is done by the microbe.

As the microbe lives only in the air, it can do its work only on the surface of the cider. A comparatively large surface of the cider must therefore be exposed to the air. The more surface, the more microbes employed, and the quicker the work is done.

By reason of this fact the vinegar of commerce is usually made by the quick process. The liquor is spread out over a large surface. Great room brings great numbers of workers. The work is done quick. But the liquor employed is rarely or never made like cider, from apple juice, but from other materials; and the vinegar is not so good. Home made vinegar from cider is the best. In the first place, the cider is home made, and is genuine. Then the work is done slowly and well. The result is excellent.

The barrel lacks a couple of gallons of being full. The bung is open. This admits air to a sufficient surface. The microbes come in from the air and begin their work. Little patches of a thin film collect at different points on the surface. These patches grow larger and larger until the thin film

covers the entire surface. This film is simply a thin network of microbes.

The members of this entire working force now,—subsisting on oxygen breathed from the air and other substances at the surface of the cider,—by their life processes convert the alcohol of the cider, first into aldehyd, and then into acetic acid, or vinegar.

The entire work may require several weeks, or even months. But when the job is complete, the owner has a barrel of the best vinegar in the world.

The work of these minute beings in making vinegar is just as natural as a similar work done by all air breathing animals, including ourselves. We breathe oxygen with the air that we may live. The oxygen in the lungs unites with carbon as waste from the blood, and forms carbonic acid, which we exhale with every breath. So the microbes of vinegar breathe oxygen from the air that they may live. The oxygen comes in contact with the alcohol of the cider, and the final result is acetic acid or vinegar. To complete the analogy, the carbonic acid which we manufacture serves as food for vegetables; and the acetic acid or vinegar, which these tiny creatures manufacture, serves as a dietetic principle in various foods which we consume.

Evidently this microbe may be, is, cultivated. In the home where vinegar is only occasionally

made, and on a small scale at that, only wild microbes from the air are used. But in factories, where large quantities are made, the tanks are arranged with pipes at the bottom. When the vinegar is complete, it is drawn off through these pipes, leaving the scum in the tanks. As the tanks are filled with new liquor, this scum,—or network of the microbes used,—rises to the surface, ready to convert to vinegar the new liquor. Thus the same colony, or colonies, of microbes, or their descendants, are carried from batch to batch, from year to year. This, long continued, must result in culture, and furnish better workers.

No doubt, too, a vinegar yeast may yet be made. In its dry form kept in the home, by its use every family may make its own vinegar as easily as its own bread.

PART III

MICROBES OF THE FARM

CHAPTER XXVIII

THE GROWING PLANT

THE Plant enjoys a kind of life as real as that enjoyed by the Animal. To support its life, the Plant takes food as really as does the Animal.

The Plant, like the Animal, has special organs for taking food,—special organs for digestion, for circulation, for assimilation.

The sources of plant food are twofold, the Soil and the Air.

Corn is planted in the soil. It germinates. One sprout grows downward, Fig. 63, seeking moisture and food from the soil. The other grows upward, seeking the sunlight, moisture and food from the air.

As the plant becomes more and more developed, the downward sprout divides and subdivides, Fig. 64,—and these subdivisions divide and subdivide again and again, until a comparatively large mass of soil, directly beneath the plant, becomes a complete network of roots and rootlets. All these thousands of minute organs act as so many mouths

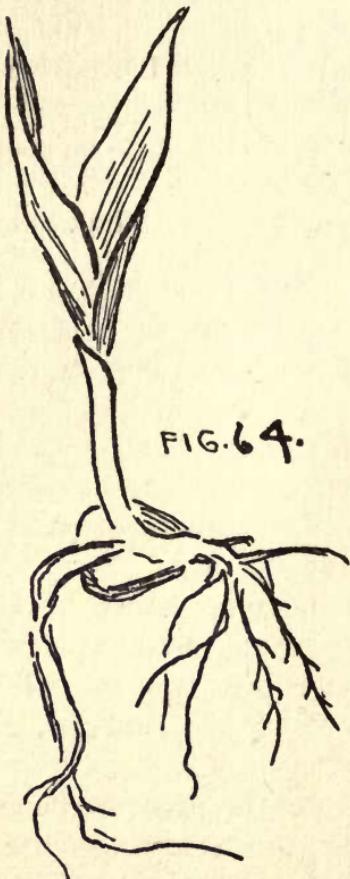
grasping food from the soil. This food enters the digestive and circulatory systems of the plant, and helps sustain its general growth.

Meanwhile, the upward sprout forms the stem,

FIG. 63.



FIG. 64.



divides into, or produces, small branches and branchlets, leaves, blossoms, pollen, and many other organs,— all of which act as so many mouths taking food from the atmosphere.

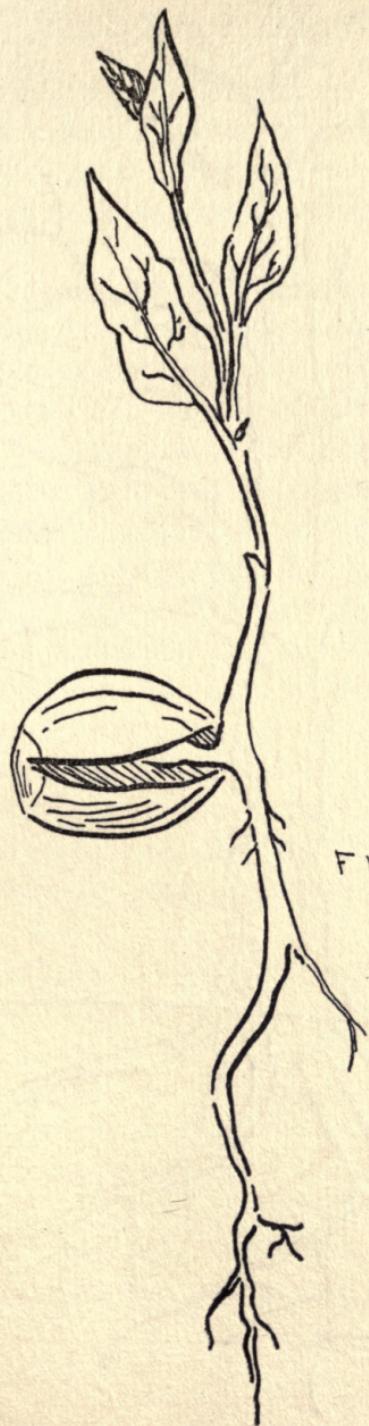


FIG. 65

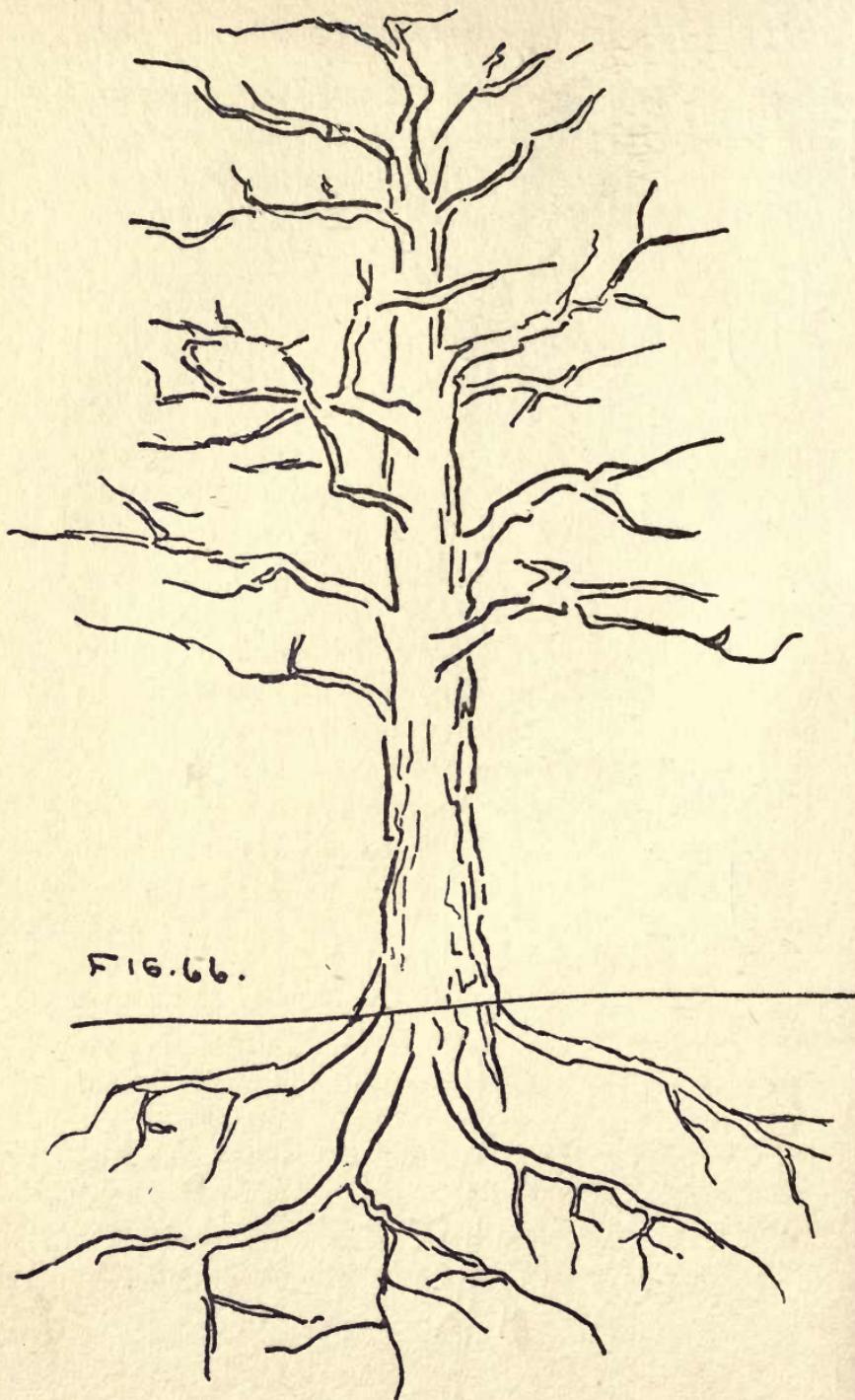


FIG. 66.

From this double source, the Soil and the Air, all crops raised by farmers over the whole earth derive food, grow and ripen, ready for the garner, to serve in turn as food for Man and his domestic animals.

So the acorn, Fig. 65, perchance falling on favorable soil, like the farmer's seed, germinates and grows. In completing the evolution, the downward sprout, Fig. 66, becomes one great mass of roots, with thousands of rootlets, occupying a large space of the soil, and extracting therefrom food for the general sustenance and support of the tree. The upward sprout, too, develops into the stem, and this divides into many lofty branches, and these into thousands of branchlets, finally ending in tens of thousands of leaves. The leaves act as so many mouths grasping food from the air for the nourishment of the oak.

Thus by this double process of extracting food from Soil and Air, all the forests are produced, which cover so large a portion of the earth's surface.

Wonderful to think that all the farmers' crops and all the forests over the whole earth were once parts of the soil and parts of the air. More wonderful to think that Man and all the animals that roam on the land, swim in the sea, or fly in the air, were also once parts of the soil and parts of the air. Most wonderful of all that machinery of Nature which has the power thus to transform parts of the soil and the air into all the Vegetable and

Animal life on the earth; and then, to change all this Animal and Vegetable life back into parts of the air and the soil, ready to make another round in the never ending cycle.

By this machinery is kept up the fertility of the Soil and the Air through the ages. Such enormous quantities of plant food are annually abstracted and utilized to keep life going on the earth that, unless Soil and Air were constantly replenished, they would soon become barren. Barren Soil and Air would soon mean barren Earth devoid of Life. But, as a matter of fact, Life has flourished all over the earth some hundreds of millions of years; yet Soil and Air seem to-day as fertile and well adapted to support Life as at any past moment in the world's history. It is only because Nature's great reservoirs annually yield up a certain required volume of plant food to support Life on the earth, while a similar volume of that food, having served its appointed mission, annually returns again to replenish those storehouses. The great cycle is forever active and continuous.

CHAPTER XXIX

MICROBES AS ENRICHERS OF THE SOIL

WHATEVER other agencies are used in keeping up the fertility of the soil, an all important part is played by microbes.

First, the ash of all plants is mineral. The bones, too, of all animals are mostly mineral. Both plants and animals, therefore, require mineral substances in their food. The animal derives this substance from the plant, the plant from the soil, and the soil from the rock.

But before the soil can furnish this substance in a form which can be appropriated as food by the plant, the rock must be crumbled and ground to powder. The molecules of the powder, too, must be separated into their atoms and the atoms recombined into other molecules forming the various mineral salts. The crumbling and powdering are done by chemical and physical forces,—air and sunshine, moisture and drouths, heat and cold, torrential stream and cataract, and the grinding power of the iceberg. But the breaking up of the molecules and the forming of new ones are affected, in part at least, by microbes.

Second, all other food furnished plant life by

the soil is, for the most part, nitrogenous—nitrogen and its compounds. This element is abundant in Nature. Four-fifths of all the atmosphere is nitrogen. All animal bodies contain sixteen per cent. of nitrogen. Plants contain still more. Animals derive their nitrogen from the plants on which they subsist. Animals, which subsist on other animals, derive their nitrogen from these other animals which subsist on plants. Plants get their nitrogen food from the soil, and the soil gets it from the air.

But microbes are the means of fixing nitrogenous food in the soil. Many species of microbes live in the soil as their only abiding place. The air presses everywhere upon the soil with the weight of about fifteen pounds to the square inch. This sends the air deeply into the soil everywhere. Some species of microbes in the soil come in contact with air, and, by their life processes, transfer its nitrogen to the soil in such form that the fine rootlets of plants get hold of it and appropriate it as food. The more nitrogen is thus transferred to the soil, the richer is the soil, and the better the crops of the farmer.

The soil in some large tracts of land becomes barren. Its crops do not pay for the labor required to cultivate it. It is because of the absence of these microbes. For some reason they have been destroyed, or removed from the soil.

Now make a pure culture of these required species of soil microbes. Prepare the culture in

powdered form. Make it abundant enough to sow with some seed, say wheat, a large tract of the barren land. The cost should not exceed one dollar twenty-five cents per acre. Prepare the soil, mix the powder with the seed, and sow. As soon as the microbes in the culture find a congenial environment in the soil, they begin to grow and multiply with great rapidity. By their life processes they transfer nitrogen from the air to the soil. The fine rootlets of the sprouting seed now find abundant nitrogenous food in the soil. The result is a good crop of wheat.

Experiments have been made along this line, especially in Europe, and with good success. It is one method of enriching the soil by the culture of microbes, — a bright promise for the future.

Another method is by cultivating the Legumes. This family of plants numbers 7,000 species. Among them are the pea, the bean, and the clover. The clover is the most prominent, and probably the most profitable to cultivate. Its roots, in connection with certain other species of soil microbes, have the faculty of extracting nitrogen from the air and fixing it in the soil. On the roots are formed minute spherical bunches. By bacteriological examination these bunches are found to be no more or less than clusters of bacteria, or microbes. Growing and thriving with the roots, these beings extract nitrogen from the air and fix it in the soil. Thus the soil becomes richer. The roots of the clover subsist on this nitrogenous matter, and thus

become rich in the same themselves. Therefore when the roots decompose in the soil, they add to the soil still further richness.

However large the crop of clover, in growing it makes the soil richer and better. The larger the crop, the richer it leaves the soil. From personal experience I know that, in the right latitudes, two crops of the medium red clover may be taken from the same field in one season. They shall each average two and a half tons to the acre—five tons from every acre in one season. Yet the soil shall be made better and richer to produce some other crop the next season. By frequently rotating clover with other crops, the soil is kept in a high state of fertility, and the farmer's ledger counts on the right side. It is because soil microbes with this crop do their best work.

The decay of all animal and vegetable bodies on the surface of the earth is a means of enriching the soil. But in this decomposition microbes are the chief actors. The microbes of putrefaction seize hold of all such bodies and literally reduce them to atoms. The carbon then unites with oxygen from the air and rises into the atmosphere as carbonic acid. But the nitrogen unites with other elements, forms nitrates which are absorbed by, and enrich, the soil. Without the aid of these microbes all dead animal and vegetable bodies would remain undissolved, and soon so encumber the earth as to render it unfit for the abode of human beings and the lower animals. But by their speedy

dissolution by microbes the soil is enriched and the round earth kept clean and sweet for the dwelling of man and beast.

Fourth and finally, the soil is made more productive by fertilizers specially prepared by the farmer. Most important among these are the compost and barnyard manure. But every farmer knows that neither of these fertilizers, in its green state, is fit for use. They must first undergo a ripening process, and this change is effected wholly by microbes. Microbes attack the green fertilizer and by their life processes reduce it to nitrates. In this condition, applied to the soil, it becomes a most excellent plant food.

The service rendered, therefore, in all these various ways by these invisible friends as enrichers of the soil, is indeed inestimable.

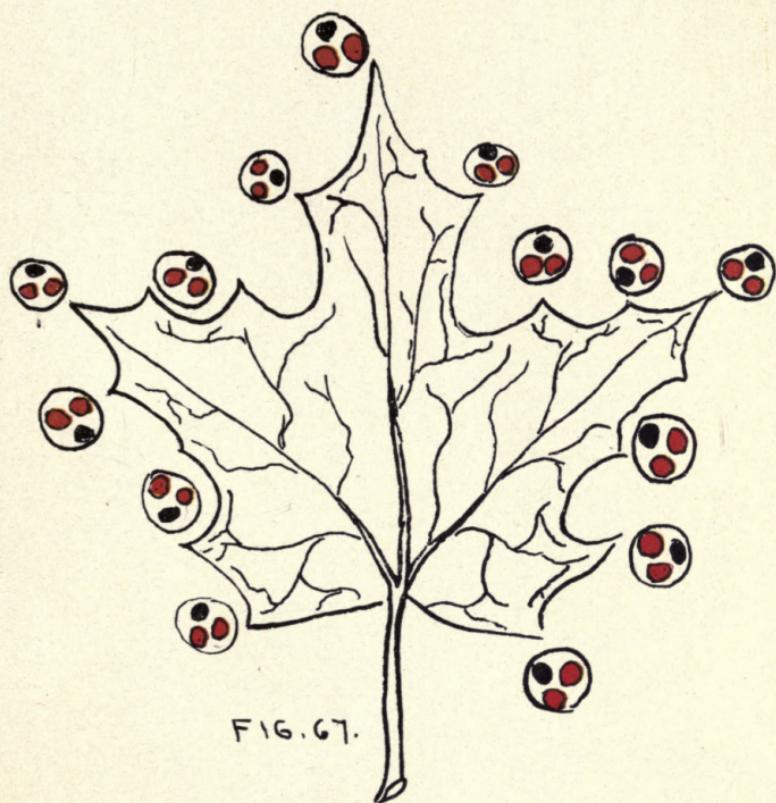
CHAPTER XXX

HOW PLANTS TAKE FOOD FROM THE AIR

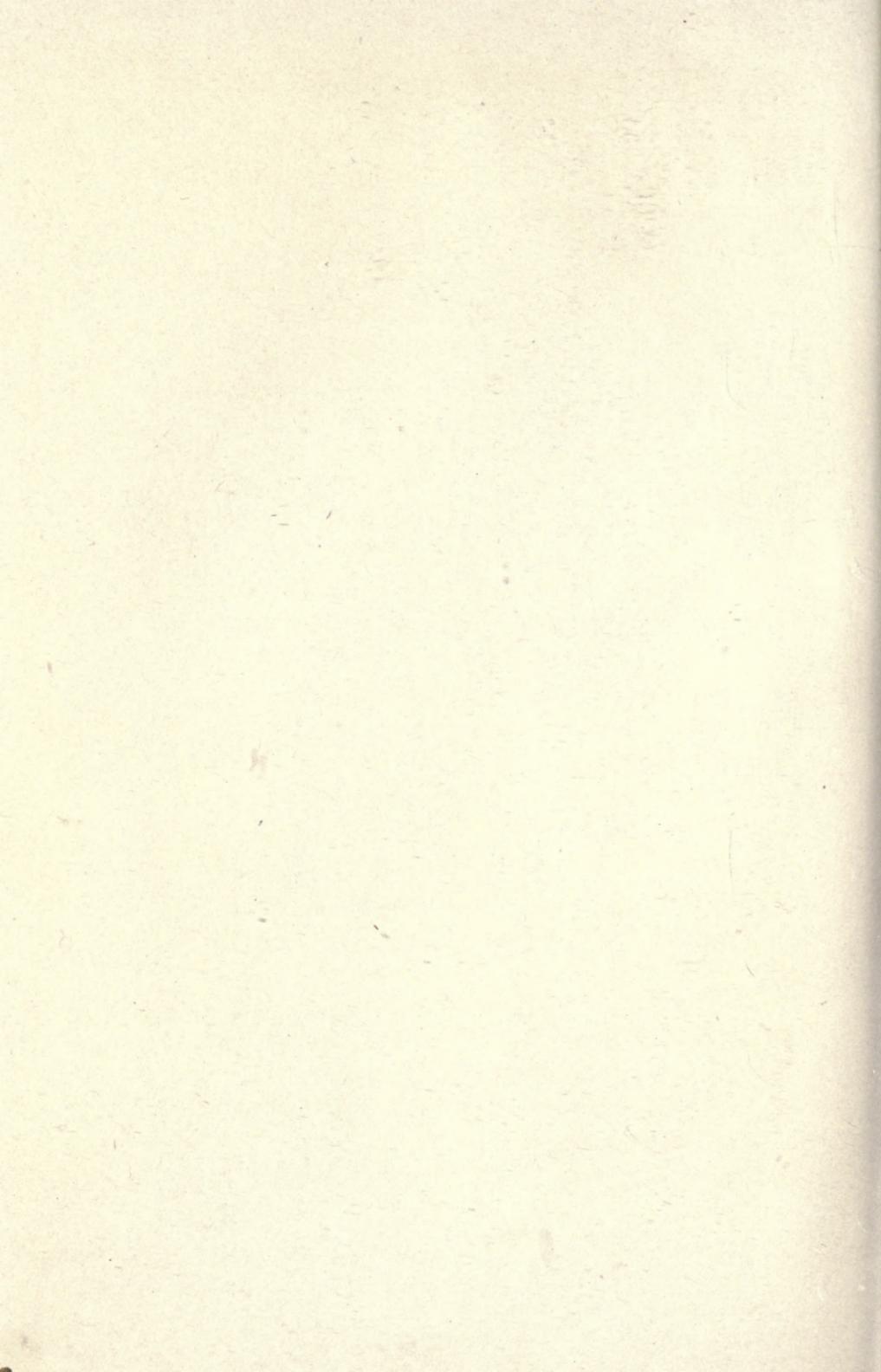
WHILE the soil supplies plants with nitrogenous food, the air supplies them with carbonaceous food. Carbon is the principal element. It exists in the air in the form of carbon dioxide, or carbonic acid. The quantity of this gas in the air is comparatively small and ever varying in amount. It is yet sufficient at all times to furnish a bountiful supply of this kind of food for the whole vegetable kingdom.

The leaves of the plant are the organs which extract this food from the air. Each molecule of the gas is composed of one atom of carbon united with two atoms of oxygen. Its chemical symbol is therefore CO_2 . The gas brings into contact with the surface of the leaf its millions of molecules. The leaf acts as the engine. The sunbeam is the motor power. The leaf, thus run, breaks up the molecule, seizes the atom of carbon and appropriates it as food. The two atoms of oxygen, thus liberated, go free into the air.

This is illustrated in Fig. 67. The Clusters of the dark and red dots represent molecules of carbonic acid. The dark dot in each molecule is the atom of carbon. The two red dots in each molecule are the two atoms of oxygen. These molecules float



THE LEAF A FEEDER OF THE PLANT



in the air. Millions of them come in contact with the leaf,—not only with the edges, as represented in the diagram, but also with the entire surface of the leaf. The leaf then acts as the machine. The sunbeam is the motor power. Thus run, the machine breaks up each molecule of the acid, seizes the atom of carbon, and appropriates it as food for the plant or tree. The two atoms of oxygen, thus liberated, escape back into the air.

The work done along this line in a season by a single leaf is of course but little. But “many littles make a mickle.” The multitude of leaves on the single tree may do a great work for the tree. The ordinary tree of the forest,—say, the maple,—contains, during the season of growth, as many as four hundred and thirty-two thousand leaves. All combined, they present to the sun a surface of 21,600 square feet, or a half acre. Each one of these leaves is a machine. Each one is separately run by the sunbeam. Each one thus picks out daily from the air, in the season of growth, millions of carbon atoms to feed the tree,—four hundred and thirty-two thousand machines run by sun power, daily doing a mighty work for the growth of the tree.

Multiply this number by the infinite multitude of trees in the forests of the whole earth. What a surface power! How great the work done! Millions of tons of carbon daily extracted from the atmosphere, to supply the growth of all the forests.

But this is only one-half. With other organs the leaves of all the farmer's crops over the wide earth,—including all pasture lands, all flower gardens, all ornamental and shade trees, every green thing outside of the forests,—present to the sun another surface at least equally as large, and daily draw from the atmosphere at least an equally large amount of carbon.

It is evident, therefore, that the air, unless constantly re-supplied, must soon become exhausted of this kind of food. With her ever ready resources, Nature fully meets the demand. Each adult of the 1,500,000,000 people who inhabit the earth throws from his lungs into the air 140 gallons of carbonic acid every twenty-four hours,—in all more than 200,000,000,000 gallons daily. The lower animals throw from their lungs every day five times as much more,—over 1,000,000,000,000 gallons. Every ton of coal burned pours into the atmosphere two and two-thirds tons of this acid,—millions of tons every day. All fires on the earth, fed by other fuel, probably furnish to the air as much more of this acid. All decaying animal and vegetable substances, too, are, chemically, so many slow fires, and furnish another vast quantity. The 2,000 active volcanoes on the earth pour into the atmosphere 2,000 great streams of this acid every moment. All the extinct volcanoes probably pour in daily as much more.

Taken all in all, how vast the quantity of this acid daily poured into the atmosphere. To us

deadly poison — to the entire vegetable kingdom delicious food. Great as is the daily supply, it is only sufficient for daily bread to the hungry Vegetable World. It goes out of the air as fast as it comes in. The Vegetable World is thus fed, so the air is kept pure.

CHAPTER XXXI

AIR FOOD AND MICROBES

THIS kind of food, traced to its original source, is found, in every instance, to be dependent, in one way or another, upon the service of microbes.

The mixing of the carbon of dead and decaying animal and vegetable bodies with oxygen of the air is a chemical change. But the decaying of such bodies is initiated and carried forward by microbes. Soon after such bodies die, the microbes of putrefaction attack them, tear asunder the molecules of their tissues, and the carbon, thus liberated, unites with oxygen of the air, rises and mingles with the air as carbon dioxide; while the nitrogenous matter, for the most part, returns to the soil.

The burning of all wood fires, too, on the earth, is the same chemical change—carbon of the wood uniting with oxygen of the air, and rising into the air as carbon dioxide. But the growth of the wood itself is made possible by microbes fixing nitrogen in the soil.

The great quantity of carbon dioxide daily produced by the burning of coal is the final result of the same chemical change; but the coal itself is of vegetable origin, and the growth of the rank vegeta-

tion whence it came during Carbonaceous times was owing to the fixation of nitrogenous food in the soil by microbes.

Likewise a similar chemical change in the lungs of all animals,—carbon of the blood uniting with oxygen of the air inhaled,—is the immediate cause of the billions of gallons of plant food daily coming into the air from this source; but all animal life is dependent on vegetable life, and vegetable life is dependent on microbial work done in the soil.

Finally, the contribution to this same air food constantly made by volcanoes is vegetable in its origin, and therefore originally the gift of microbes.

Thus, which ever way we turn, we find these invisible friends, primarily, are indispensable to the supply of atmospheric plant food.

CHAPTER XXXII

FOOD CYCLES AND MICROBES

As represented in Fig. 68, the atmosphere, as a whole, surrounds the earth as an envelope 45 miles, — 237,600 feet, — high. It is composed chiefly of four parts, — water, carbon dioxide, oxygen, and nitrogen. These parts are not chemically combined, but only mixed together mechanically.

The air is densest at the sea level. From this point upward, it becomes rarer and rarer, until, at the top, it is exceedingly rare.

Now it is estimated that, if compressed from the top downward until the density should be the same at every point, the atmosphere would be but five miles high. It is further estimated that, if its different parts should then be separated, one from another, and arranged in layers from the bottom according to their specific gravities, the layer of water would come first, and cover the earth five inches deep. Next would come the layer of carbon dioxide, thirteen feet deep. Next the oxygen layer, 5,280 feet deep. Finally would come the nitrogen layer, 21,120 feet deep. Fig. 69 represents simply the order of the layers, not their relative thickness. But each layer further represents a distinct cycle of food.

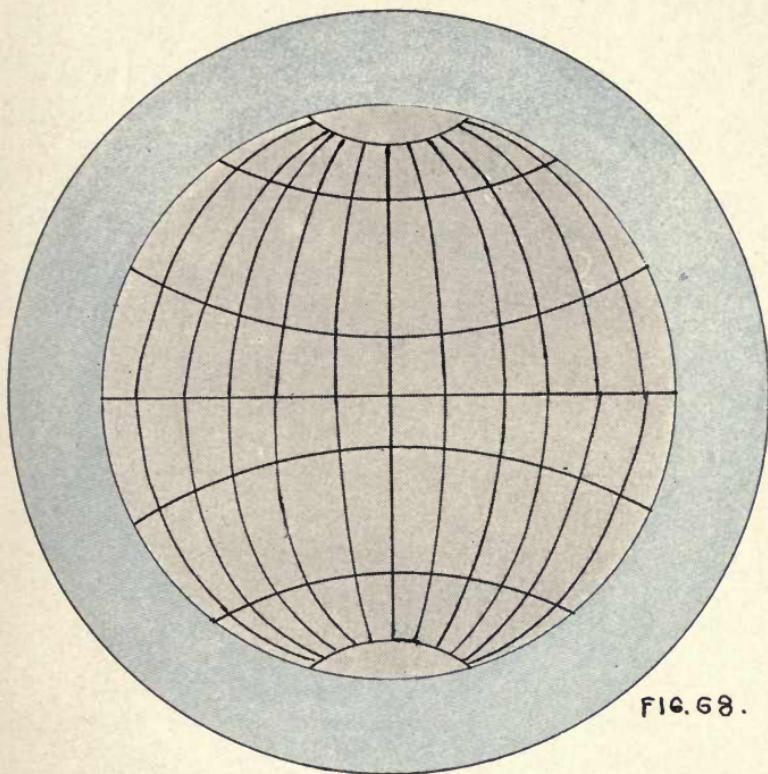
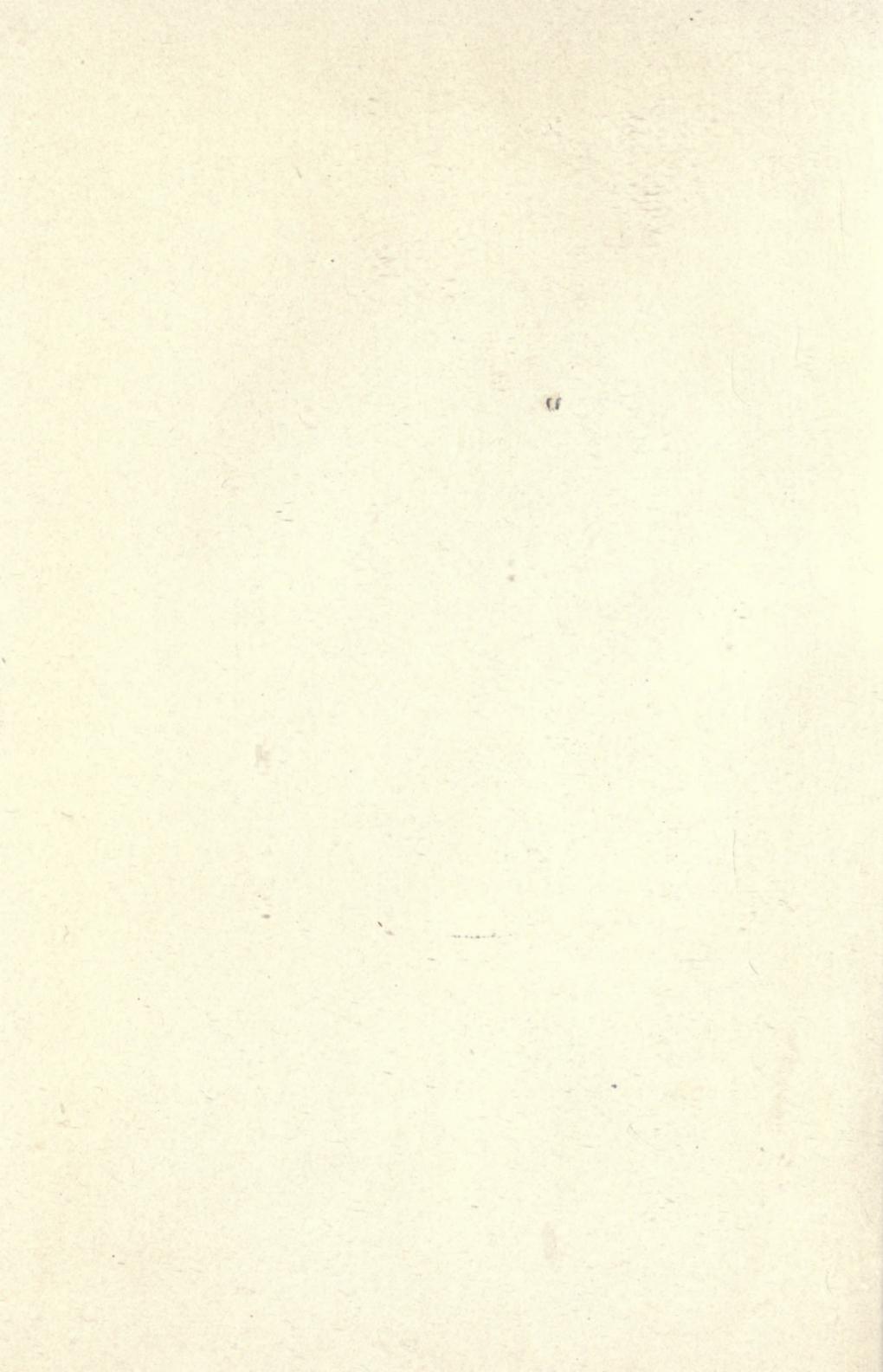


FIG. 68.



Plants feed on the water in the air. They absorb it largely by their roots, stems, branches and leaves. They could not live and grow without it. Animals living on plants appropriate the same water and much more. When plants and animals die and are dissolved, the water returns again into the air, ready for another round in the water cycle.

Of course there is another larger water cycle. By evaporation water is drawn up by the sun into the air from all the seas, and falls on the land as rain, dew and snow, and returns again in rivers to the seas, ready for another round in the greater water cycle.

Through the agency of their leaves, plants take carbon from the air,—under the influence of the sun picking the carbon atoms from the molecules of carbon dioxide,—and appropriate it as food. Animals live on plants and incorporate the same food into their own systems. When both plants and animals die, during the dissolution of their bodies the carbon therein unites with oxygen and returns again as carbon dioxide into the air, ready for another round in the carbon cycle of food.

Great quantities of oxygen are taken from the air, day by day, moment by moment, to feed hungry vegetable mouths. Every animal that breathes, by virtue of lungs, spiracula, or gills, breathes oxygen. Every fire that burns, burns oxygen. Every decay of animal or vegetable substance is a slow fire consuming oxygen. It is estimated that for these three purposes not less than 7,000,000 tons

of oxygen are taken from the atmosphere every day.

But, day by day, moment by moment, all this stream of vital fluid, is poured back again into the air. While in the breathing organs of all animal life oxygen seizes upon the waste material, or used up carbon, loads up with it, and returns to the air as carbon-dioxide. While in the flame of every fire that burns oxygen seizes the carbon of the fuel, loads up with it, and returns to the air, as carbon dioxide. While, too, in every slow fire of decaying vegetable or animal body oxygen again seizes the carbon of that body and carries its burden back to the air as carbon dioxide.

Then, all this carbon dioxide returned to the air, day by day, moment by moment, yields up its carbon as food to the vegetable kingdom, and, day by day, moment by moment, the 7,000,000 tons of oxygen are being set free in the air, ready to speed again on its journey through the rounds of its food cycle.

So as the air presses deeply into the soil, great quantities of its nitrogen are absorbed by the roots of plants as food. As animals devour the plants, the nitrogen becomes a part of their systems. As plants and animals die, and their bodies are decomposed, all this nitrogen is liberated, and again finds its way into the soil, ready for another round in its food cycle.

All these food cycles are constant, eternal. No break in the endless chains. To their keeping is

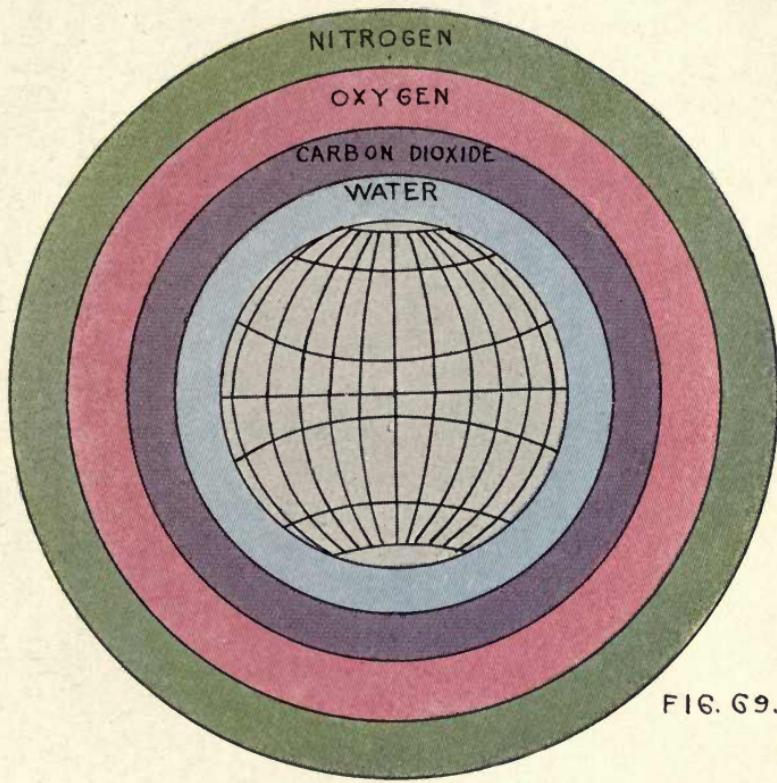


FIG. 69.

committed all life on the earth. The air is the great storehouse. From this bounty these guardian angels carry full sustenance to every living being that walks the earth, wings the sky, or swims the sea. Blockade one—all is over. The round earth is dead. No spark to send one ray into the blackness of desolation.

In the solar system stop one planet in its course, that system goes to smash. In the system of life on this round earth stop one food cycle, that system ends with a crash. Happily, run by sun power, the continuity of each cycle is assured.

But where do microbes come in? The least and lowest of all beings, what have they to do with these giant life-preservers? Fed, themselves, by these endless chains of food, in each chain they form a most vital link. Break that link, all is paralyzed.

Water, carbon and nitrogen, in going the rounds of their cycles, are detained on their way, as before stated, to serve the vegetable and animal kingdoms as food. Thus they become imprisoned in the bodies of plants and animals. Here they would be forever chained, were it not for the microbes of putrefaction. As soon as life becomes extinct, these beings seize the dead bodies, open the prison doors, and make it possible for chemical forces to do the rest. Thus, by virtue of these tiny cleansers of the earth's surface, these three cycles, — water, carbon, nitrogen,— move on, free, complete, permanent, forever.

But what have microbes to do with the oxygen cycle? As much as, more, if possible, than they have to do with the other cycles. True, oxygen in the air inhaled into the breathing organs of every living animal on the earth, there unites with carbon and is exhaled back into the air as carbon dioxide. And the change in the organs is strictly chemical. It is two atoms of oxygen uniting with one atom of carbon, forming the molecule of the carbon dioxide. Microbes have nothing to do with it.

True, in every fire that burns the same change takes place. It is chemical. Microbes do not touch it. Oxygen from the air unites with the carbon as the fuel burns, and comes back into the air as carbon dioxide.

True, too, in the decaying of every vegetable or animal substance oxygen from the air unites with the carbon of the burning fuel, and returns to the air as carbon dioxide. The change here, too, is chemical,—exactly like the changes in the two previous cases. Two atoms of oxygen lock arms with one atom of carbon, thus making up the molecule of carbon dioxide.

True, it may be, that, in supporting these three natural fires, 7,000,000 tons of oxygen are taken from the atmosphere every day. If so, true it also is that 14,200,000 tons of carbon dioxide are poured from these fires back into the atmosphere every day. True it is that all this sea of gas, spreading itself in the air over the land, is used up every

day as the daily bread for the Vegetable Kingdom. True it is that here, again, in this great change only chemical and physical forces are employed. Microbes lend no aid. Leaves of the plants, engineered by sun power, break up the molecules of the 14,200,000 tons of carbon, and let the 7,000,000 tons of oxygen go free back into the air whence it came.

But what of it? What if microbes have nothing to do with these chemical and physical changes? It is yet true that, all the while, these changes are taking place, microbes are doing a more basic work. Their work in the grand order of this oxygen cycle is first. All the work done by the chemical and physical forces rests upon this previous work done by microbes as on a foundation stone. In each of the three chemical fires — in the breathing organs of animals, in the furnace where coal or wood is burned, or in dead bodies, — the carbon in each case which makes the fire possible, is vegetable in its origin. But the growth, and the very existence of the vegetable, in each case, is made possible only by the fixation of nitrogenous food in the soil by microbes.

This cycle of oxygen, therefore, like the other food cycles, is made complete and permanent, and the order of life on the earth maintained, only by the helping hand of our Invisible Friends.

CHAPTER XXXIII

CUMULATIVE SERVICE

IN retrospect, to take a bird's-eye view, is seen, at a glance, a service as cumulative as are the wants of life. It covers the whole field. The finer qualities of bread on the table, the choicest flavors of butter and cheese, the appetizing vim of cider and vinegar in their varied uses,—are the gift of these beings. To them do we owe the sparkling wine, the foaming beer, the stimulating brandy, whiskey and gin,—the thousand and one uses of alcohol throughout the world.

Back of all this, they serve to enrich the soil, and thus to produce the crops that grow on the face of the whole earth. They do more. They serve to make this bounty perpetual. Owing to their help neither the Air nor the Soil becomes exhausted. From day to day, from age to age, the same fertilizing materials are re-born, renewed, and made fresh as ever, to feed again and again the entire vegetable and animal kingdoms forever. In these eternal food cycles microbes form an essential link.

Our environment in the Visible World consists largely of plants and animals. Were it not for these, we could not live. But this environment is

based upon, and springs from, another environment within the Invisible World. Were it not for the Friends of this invisible environment, nor plants, nor animals, nor ourselves could exist.

BOOK THIRD
OUR INVISIBLE FOES

PART I

MICROBES OF THE NOSE, THROAT AND LUNGS

CHAPTER XXXIV

MICROBE OF THE COMMON COLD

COLDS are "catching"—a popular impression. In this matter people are coming to the front,—they see, think, conclude.

Why should they not? Before their eyes, one member having a cold, that cold usually goes through the family. One member catches it from another.

Before their eyes the same cold frequently becomes epidemic—the whole community catches it.

Before their eyes nurses in tuberculosis sanatoriums dread to have friends, having colds, visit their patients. The patients are almost sure to take the colds.

Before their eyes Arctic explorers, while in the arctic regions, have no colds,—no people there from whom to take the cold. As soon as they return to civilization, the explorers have bad colds, taking them from the people with whom they mingle.

From such facts up-to-date thinkers realize and know that colds are infectious; they are communicated from one person to another.

This being the case, the cold is always caused by a germ. The germ, and the germ only, renders the cold infectious. The germ, and the germ only, is communicated. At least, if anything else that is lifeless is communicated, it cannot produce disease. A speck of dust, or a speck of sputum, in itself alone, communicated from one person to another, can do no harm. It is dead, and cannot multiply. But a living germ, passing from one to another, may grow, multiply and become millions in the second person. This poison, according to its nature, produces the cold, or any other disease. Sparks fly from one burning building to a second; from the second to a third; from the third to others. A conflagration is the result. Germs pass from one person to a second; from the second to a third; from the third to others. An epidemic is the result.

Other means may prepare the way for a cold—sitting or standing in a current of air, a sudden chill, undue exposure to wet and cold. But such things only cultivate the soil. The germs must yet be planted in the soil before the cold springs up.

Three kinds of colds. It may be, at times, three stages of the same cold. The first plays the game of simple secretions from the nose and throat. The second adds soreness of the throat. The third adds a cough.

Each kind of cold is due to its own kind of mi-

crobe. Three kinds of microbes are the active causes—it may be three varieties of the same species.

The first cold may last three, the second, six days; the third, three weeks.

But what will you do? "Doctoring" is out of order. Drugs are a curse. In nine cases out of ten, the best thing to do is nothing. Anyway, take good care—always this, especially when ill. Dress warm. Keep warm. Flannels next to skin. Live on a laxative diet, with plenty of fruit. Breathe good air. Sleep with the window open.

Next time don't take cold. Avoid the means by which the soil is cultivated. If a member of the family happens to get a cold, kiss not. Take not his breath. Drink not out of the same cup. In many little ways set up a pretty quarantine. Smile at it, if you will, but do it.

CHAPTER XXXV

MICROBE OF THE INFLUENZA

THE term influenza, as here used, signifies a special affection of the nasal organs. Occasionally it extends to the throat, but usually it is confined to the cavities of the nose. Rarely, if ever, is it attended with any cough, or soreness of the throat. A distinct species of microbe is the cause. Fig. 70. The period of incubation, like that of the cold, is from twenty-four to forty-eight hours. Like the cold, it may last three days or three weeks. In other respects it is widely different from the cold. The cold comes on gradually, the influenza suddenly. Its onset is terrific — like a hurricane. Violent sneezing, profuse secretions follow one another in rapid succession. The spasms may be repeated once, or several times, a day.

I know what I say. A barber clipped my moustache. From his clippers I breathed influenza foes. In forty-eight hours in my nasal cavities came a thunder storm. It whizzed and buzzed. It roared, and it poured. Twice, or more, every day for two weeks, this head tornado recurred. It left as suddenly as it came. Never since have I seen the inside of the "deadly barber's shop."

This is the influenza. It numbers its victims by the thousands.

What will you do? Take no drastic medicine; only harm will result. Call no doctor—he might bring another disease. You will then regret the complication. By itself, the influenza is harmless. The other disease may work mischief. Therefore, as with the cold, just keep quiet. Dress warm. Keep warm. Eat laxative food. Day and night breathe pure air. Take proper exercise. The foes generate poison. This afflicts you, but it afflicts them worse. By their own poison they soon destroy themselves. That's all.

CHAPTER XXXVI

MICROBE OF THE GRIPPE

THIS microbe ranks among the smallest of pathogenic germs — about $1\frac{1}{2}$ micro-millimeters in length by $\frac{1}{10}$ of a micromillimeter in thickness. This means that over five billions of them may be packed within the space of a cubic millimeter, or small drop of water. They belong to the Rod-shaped type. Fig. 71.

In one of many ways possible, one or more of these tiny beings get into the nasal or throat passages. Here they find a congenial environment. They at once begin to thrive and grow and multiply. Each one prolongs itself. In twenty minutes each one divides and becomes two. In twenty minutes more each of these two becomes two, producing four. At this rate, in twenty-four hours each one becomes 16,500,000; in forty-eight hours, 281,500,000,000.

In their life processes these germs generate the grippe poison. It is this poison, and this alone, that does all the mischief. It is of three kinds, arising no doubt from three varieties of the same microbe.

Hence three varieties of the Grippe. The first is mild. It resembles the common cold; but it works more upon the nerves, and is prostrating

The second is more catarrhal, and its victim is more prostrated. The third is malignant. It affects the nasal organs, the throat, lungs, the whole system, and not unfrequently proves fatal.

Many people suffering with the Grippe are apt to spit where the sputum becomes dry before it is taken care of, in the home, on the sidewalk, in the car. This sputum is always filled with microbes. When it dries, the microbes, clinging to particles of dust, may rise into the air. Breathed by others, the disease spreads. This is the most common way of taking it.

Hence the Grippe is exceedingly contagious and infectious, and usually becomes epidemic. Not unfrequently it goes round the world in waves. Such waves are recorded in all historic times. In recent times are notable examples. The mention of one is sufficient.

Nov. 1st, 1898, the disease breaks out in Russia. In three days, it prevails over the entire empire. In three weeks more, it spreads over all Europe. In five days more, it appears in New York. In fifteen days more, 200,000 persons in that city have the Grippe, and, at the same time, it is raging over this whole country. Thousands upon thousands of fatalities are the result. The infinitely small germs float in the air. They are breathed. The disease goes like a whirlwind.

The common cold is like the steady storm. It spends its force, and is gone. The influenza is the blizzard that rages violently, but goes as

quickly. But the Grippe is a cyclone, going round the whole earth like lightning, and leaving devastation in its path.

The cause of the Grippe, as a microbe, was discovered in 1892. Since then the world has waited for the discovery of its antitoxine. When that comes, it will be the universal remedy. All that is needed is something to destroy the poison as fast as it is generated in the system by the microbes. The antitoxine, when it comes, will do that.

Till then, treat the milder forms of Grippe simply as a cold. Aside from good care, nothing. But the malignant form is more serious. The bed in a warm, but well ventilated, room is the place. Call only the up-to-date physician. Probably coming from patients with other diseases, he will at least leave his hat, coat and gloves in the hall. He will also sterilize his hands by washing them in some disinfectant. If he takes your temperature, he will first sterilize his thermometer. By such precautions he will not bring to you the germs of other diseases. Probably in nine cases out of ten where the Grippe is complicated with other diseases, these diseases are brought by the attending physician, who is at least fifty years behind the times.

The up-to-date physician will also give you wise counsel, and administer only mild medicines—medicines which, if they do not cure, will not kill you.

Under such treatment, with skillful nursing, the chances for recovery are the very best possible.

CHAPTER XXXVII

THE MICROBE OF BRONCHITIS

As represented in Fig. 72, the trachea, or wind-pipe, a, divides into the two bronchi, b, b. The right bronchus subdivides into tubes, the tubes into still smaller divisions, and the divisions continue until they coalesce with, or form, the right lung. So the left bronchus divides and subdivides in the same way until it forms, and unites with, the left lung.

Now it sometimes happens that the lining membranes of the bronchi and the bronchial tubes become inflamed. This inflammation is called bronchitis.

The disease is not uncommon, and not unfrequently it proves fatal. In the United States about 20,000 die with the bronchitis every year. At this rate throughout the world, about 400,000 must die with it every year.

Therefore it is important that one should thoroughly understand and guard against this disease. It is strictly microbian; that is, it is caused by a certain kind of microbe. It is, in fact, to the bronchi and bronchial tubes what the cold or the influenza is to the nasal and throat cavities. It is contracted and develops in a similar way. By con-

tact, or by breathing, the microbe finds its way to the bronchial organs. Here, with its true nourishment, it grows and multiplies until it becomes mil-

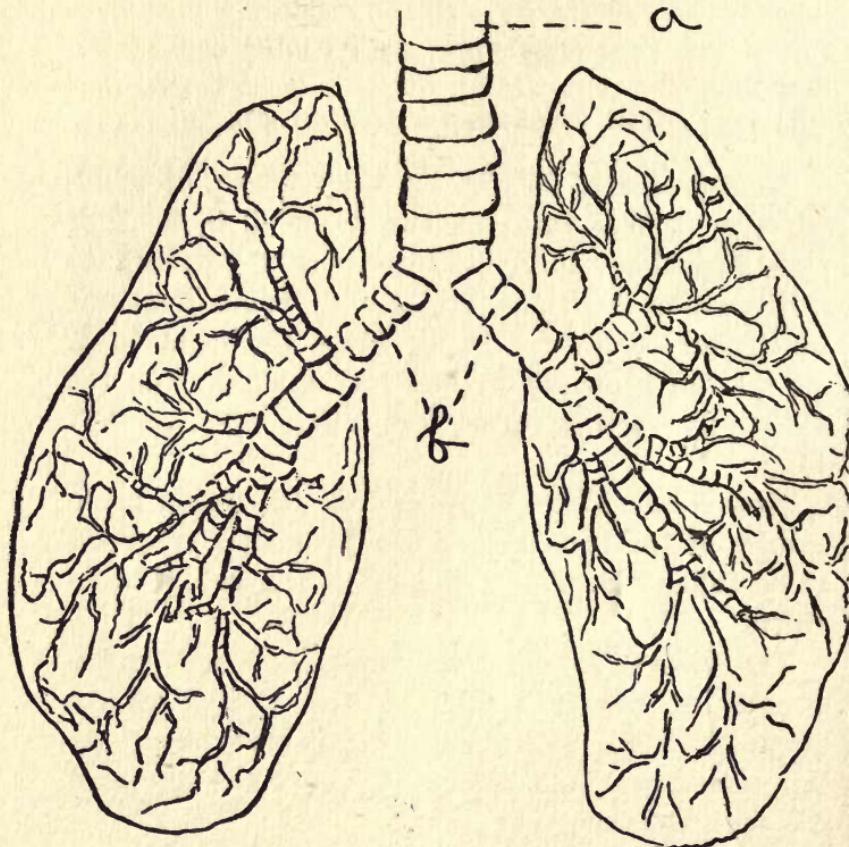


FIG. 72

lions upon millions. By their life processes these beings generate a certain poison. This poison produces the inflammation and all the attendant mischief. Mucus is generated in the bronchi and

tubes, followed by coughing as an effort to expel it.

There must of course be a true antidote for the poison generated by the bronchial microbes. When this is discovered, it will be the desired antitoxin. The application will likely be in the gaseous form by inhalation. It will thus come in direct contact with the germs and destroy them. The patient will be relieved. If this natural remedy is not already discovered, it soon will be.

Meanwhile, do not become a victim to experiment. Every drug, though ordered by a physician, is only a gilded guess. It may hit wide of the mark. Every bottle of "patent medicine warranted to cure," is only a gilded lie. It beguiles only to cheat and rob. A quack may offer his inhalent as the balm of Gilead sure to bring again to your face the old rosy blush of health. Touch it not! Ninety-nine chances to one, it would only irritate the bronchial organs, nourish the foe, and make the poison more virulent.

What then? Have infinite patience and courage. You cannot have Nature's first remedy; man has not yet unlocked its secret. Fall back on her secondary remedies. Inhale only her purest air. Not only breathe naturally, but practice forced breathing. Breathe deeply; inflate the lungs to the utmost. Expel the air. Inhale and expel again and again, for some minutes. Then rest. Repeat this exercise several times each day. It will do something to counteract and destroy the

poison which the enemy is pouring into your blood. Eat nourishing, wholesome food — all you can digest and assimilate. It will help sustain and build up what the foe is tearing down. Take daily exercise in the open air; it will tend to revitalize and tone up a system wasting by disease. Withal, take regular and good hours of sleep; it will restore wasted energy and keep you well armed bravely to continue the battle.

With such means, "Hold the fort." Never give up. Conquer and expel the foe. Life, health, years of happiness shall be your reward.

CHAPTER XXXVIII

MICROBE OF THE WHOOPING COUGH

THE sole cause of the whooping cough is a microbe, Fig. 73. Every new case comes from some previous case. The disease is exceedingly contagious and infectious. It may be taken by coming in contact with one who has it; or, as the germ floats in the air, the disease may be taken by merely going into the presence of one who has it. One scholar having the whooping cough in a school-room, may give it to every other scholar in the room.

The primary cough may continue three weeks before the whooping begins. During this time the cough may be taken for a simple cold; yet it is all the while contagious and infectious. Hence the danger of spreading the disease. After the whooping begins, the cough may continue six weeks more,—all the while infectious, nine weeks in all.

The period of incubation is fourteen days; that is, from the time of exposure to the time of beginning to cough.

In the United States about 10,000 die every year with the whooping cough. This means 190,000 throughout the world. Nearly all these deaths occur among children under four years old; two

thirds of them among children under two years of age. Adults rarely have the disease. It may be because most adults have it while young. As a rule, no person has it but once.

With young children, especially infants, the disease is severe,— quite as much to be dreaded as any other disease. Of course the severity varies from the mildest form, which seems not much worse than a common cold, up through some grades to the most severe, which most always proves fatal. In the severer cases, when the whooping begins, the coughing spells are frequent and violent. With each spasm the child may cough and whoop several times. Tears may fall from the eyes; sometimes blood from the nose; occasionally with vomiting. These spasms may occur from five to fifty times every twenty-four hours. Suffocation will sometimes seem imminent.

But do not be frightened. These spasms are the effort of Nature to throw off the poison generated by the microbes. Do not call the doctor; the mother is the best doctor. Keep away all drugs; they can only do harm. Especially keep away soothing sirup; it may soothe to sleep — soon to the eternal sleep. It may kill pain — nine cases out of ten, the patient, too. If you have any in the house, throw it to the dogs, but tell them to look out; it may stupefy and kill them!

The one thing needful in these extreme cases is intelligent, kind, constant nursing. Be with the child at all times, day and night. Keep out doors

as much as possible. In the open air the child has the fewest spasms. While in-doors, thoroughly ventilate. Dress warm, and keep warm at all times. Give plenty of nourishing food. By such means, if by any, may you help to sustain the strength of the child, and enable it "to pull through."

Every case of whooping cough should be quarantined. Only in this way can the disease be stamped out, and the innocents saved from slaughter.

CHAPTER XXXIX

MICROBE OF THE MUMPS

THE two glands, one on each side of the face, are called the parotids. They extend back on both sides to the angle of the jaws. The inflammation of one or both of these glands is known as the mumps. One side of the face is affected. It swells up, and the swelling continues a week. Then the other side swells, and continues in the same way another week. Or the disease may be confined to one side, the other not being affected at all.

The disease is contagious and infectious. From the person suffering one may take it by contact, by occupying a chair which has been occupied by him, by breathing the air in the same room, and in many other ways. If a scholar who has it attends school, he exposes all the other scholars.

The period of incubation varies with different individuals. Some may come down with the disease in ten days after exposure. Others go longer; some, twenty days.

The person is infectious, or may communicate the disease to others, any time during fourteen days after the disease begins.

In ordinary cases no doctor is needed. He can

do no good. Take liquid food. To masticate gives pain. Avoid acids. They increase the saliva, which gives pain. Keep warm. Avoid all exposure to taking cold.

In some cases the inflammation may extend to certain other glands on the body. Then a physician should be consulted.

The only way to prevent the disease from spreading is to quarantine the patient, and, when the disease is finished, thoroughly disinfect room, bedding, and all clothing.

CHAPTER XL

THE MICROBE OF MEASLES

THIS microbe attacks the organs of the throat. Here it grows, multiplies in great numbers, and thus generates the peculiar poison which produces the disease. The first symptoms are similar to those of the common cold — coughing, sore throat, discharges from the throat and nose, watery eyes, with some fever. In three days so much poison is generated that it enters the circulation and spreads through the whole system. Then comes the eruption of red blotches, the size of a pin head. Because the face is nearest the throat, which is the center of attack, the eruption first appears in the face, and then spreads over the entire body.

The disease is very contagious and infectious. The germs float in the air. This makes the disease readily taken by breathing the air in a room where the patient is. Cases are on record where a single scholar has given the disease to every other scholar in the room, including the teacher. They all are taken with the disease at the same time. Such examples show how infectious is the disease. And this is the reason why the disease is so epidemic. Usually confined to children, one or two cases generally spread it through the neighborhood.

The disease appears in fourteen days after exposure. The patient is infectious from the time the disease begins until the scaling and eruption disappear.

As a usual thing, no medical advice is needed. Good nursing is enough, and the best thing. The patient in bed. A warm room, well ventilated. Absolutely no exposure to taking cold. Liquid or semi-liquid food.

But in severe cases it is wise to consult a physician.

The mortality from measles is considerable — about 13,000 deaths annually in the United States. At this rate, in the whole world the number would be about 240,000.

Yet this disease is preventable. By rigid quarantine of every individual case all epidemics could be prevented, and the disease finally stamped out. It would seem that the yearly saving the lives of 240,000 persons, though mostly children, should be a sufficient inducement to warrant the quarantine.

CHAPTER XLI

MICROBE OF THE LOCKJAW

THE bacteriologist calls this germ "Bacillus Tetanus." Plain English calls it the microbe of the lockjaw. It is the sole cause of the lockjaw.

The germ is represented in Fig. 74. In form, it is simply a little straight rod. It propagates by the production of spores. One end of the little rod begins to enlarge. In it exceedingly minute round balls are forming. They are surrounded by a thin covering. As they grow, the end enlarges. As they attain full size, the rod assumes the form of a drumstick, as seen in the Fig. When the spores are ripe, the covering bursts, and the spores flee away, to form new rods and new spores. So, under favorable circumstances, the multiplication goes forward to any extent.

This germ is a soil microbe. It is found in a state of nature in the soil,—garden, field, or road soil. Or, even in heaps of manure.

It causes the lockjaw not only in man, but also in some of the lower animals, especially the horse.

The only known way by which infection takes place is by means of a wound. In order to produce the disease, the microbe must enter the circulation, and it is known to enter the circulation

only by a wound. The wound may be considerable, or very slight. The least breakage of the skin is sufficient. The necessary condition is that the instrument with which the wound is made shall be contaminated with soil which contains the microbe. The microbe is thus introduced into the wound, and hence into the circulation. Once in the circulation, the germ begins to grow into rods, the rods into drumsticks, the drumsticks to produce spores. These spores grow, ripen and produce other little rods, drumsticks and spores. These new germs likewise multiply. The work goes rapidly on. Soon great numbers result. In their life processes they generate the peculiar poison which produces the disease.

Bacteriologists tell us that of all the poisons known to man the poison generated by this microbe is the most deadly. This of course is the reason why the lockjaw is so fatal, and kills so suddenly.

In driving your horse, he stumbles, falls on his knees, and gets up with a slight wound. The wound is contaminated with soil containing these microbes. They enter the circulation. They grow, multiply, generate the poison. The poison seizes the muscles of the throat and jaws. The jaws are locked, the poison grips every muscle and nerve in the body. The horse is dead.

Among his fire crackers, the Fourth-of-July boy has the inevitable cannon. The deadly foe is in the explosive. The boy explodes the cannon. The

cannon explodes his finger. The foe is in the boy's blood. His jaws are locked. The boy is dead.

The man gets a sliver into his finger. The sliver is tarnished with the soil containing the invisible producer of the deadliest poison. The foes multiply and rejoice in the man's blood, but the widow mourns a dead husband!

What will you do? Until recently, nothing. Recently, the real antitoxine for this disease has been discovered and manufactured. The up-to-date doctor keeps it on hand. The moment you find you are infected, send for him. If he injects into your veins the right dose of this antidote, and repeats it just right, you live. If not, you die. That's all.

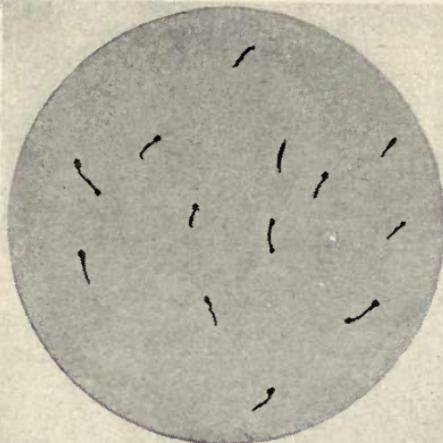


FIG. 75.

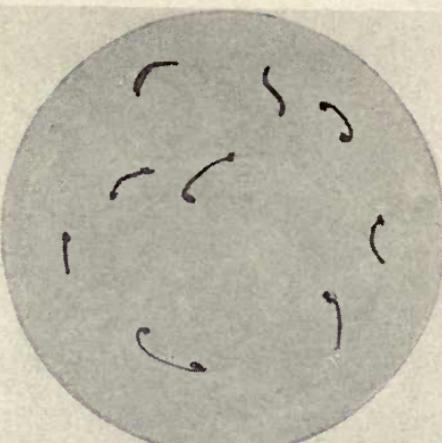


FIG. 76.

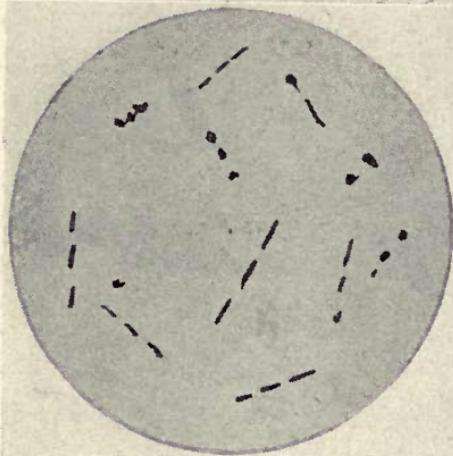


FIG. 77.

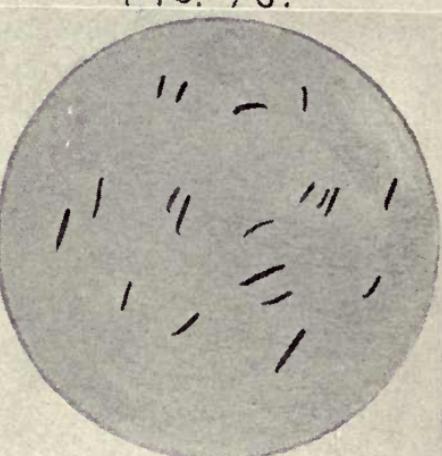
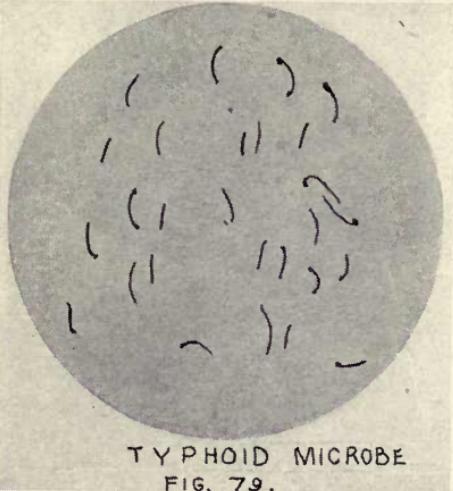


FIG. 78.



TYPHOID MICROBE
FIG. 79.

CHAPTER XLII

THE MICROBE OF DIPHTHERIA

ANOTHER deadly foe. It is Rod-shaped. The rods are slightly curved. One end is sometimes a trifle enlarged. Sometimes both ends. It is exceeding minute. A million rolled into a little ball, the ball would be no larger than, if as large as, a common pinhead. It is rudely illustrated in Fig. 75.

Yet this tiny being destroys the lives of not less than 300,000 persons every year. Probably many more. The majority are children. It is again "The Slaughter of the Innocents."

The disease makes its appearance two days after infection. The patient may give the disease any moment after its appearance until fourteen days after the patient is apparently well.

Many are the ways in which the disease may be communicated. By contact of course, but in many other ways.

In the dry form, this germ may live many years — perhaps indefinitely. In furniture it may live almost any length of time. A child two years old died with the diphtheria. While sick, it occupied the cradle. After its death, the cradle was placed in the attic. Seven years after, the family was

visited by a friend having a child the same age. The cradle from the attic was occupied by the child. From it the child took the diphtheria, and died.

The germs may be carried in clothing or on the hands. The attending physician, if not disinfected, may so convey them from house to house.

From the patient's room flies may carry the germs to other rooms in the house, and to near neighbors.

Pet cats and dogs may carry the germs in their fur, transfer them to other pet cats and dogs on the street, and these last carry them home. This may explain why not unfrequently a case of diphtheria mysteriously occurs in a family where it would be least expected. The pet cat or dog is responsible.

The germs may be transferred in water. A city or village takes its water from a certain stream. Above the intake pipe on the stream is a case of diphtheria. The germs find their way into the stream and into the intake pipe. Among the users of the water in the city or village an epidemic of diphtheria is the result.

The disease may be communicated in milk. The dairyman washes his cans in water taken from a brook contaminated with the germs. The milk is contaminated. Among its consumers is created an epidemic of diphtheria.

Or cows drink the polluted water. The germs live in their systems, appear in the milk, produce the epidemic.

The air is also a means of carrying the germs and spreading the disease. Every bit of excretion from the throat or nose of the patient contains large numbers of the invisible foes. Unless at once destroyed, these excretions quickly dry on cloths, the floor, or elsewhere. Then with any little stir of broom, brush, duster, they are reduced to powder, and with dust, rise into the air. The air is breathed; the infection takes place.

But by whatever means the deadly foes get into the human system, once there, they find their way to the throat, there make their attack. The membranes of the throat are their natural nexus. Here they locate because here they find their choicest food. They propagate by Fission. Each one grows a little longer, divides, becomes two. In the same way the two become four. This doubling takes place every twenty minutes. At this rate, one, in twenty-four hours, becomes 16,500,000. In multiplying, these germs create white patches, sometimes a false membrane, in the throat. The patches and membrane contain millions upon millions of the germs. By their life processes they generate the deadly poison. This, entering the circulation, is the stuff which sickens and so often kills.

Fortunately, the real antitoxine for this dreaded disease has been discovered. The up-to-date doctor keeps it on hand. The moment you suspect the disease in your home, call this doctor. The right dose of the antitoxine administered in season, and

rightly thereafter, destroys the poison. The patient recovers.

But the best way to cure this disease is to prevent it. If, in spite of all precautions, it does come, enforce a rigid quarantine. None but parent, nurse or doctor shall enter the room. Kill every fly in the room, and every one that enters. Throw the pet cat or dog out doors, and keep them out. As soon as the disease is ended, thoroughly disinfect house, furniture, clothing. After this, the recovered patient must not go into public for fourteen days.

CHAPTER XLIII

THE MICROBE OF PNEUMONIA

PNEUMONIA is one of the worst and most dreaded diseases man has to fight. In the United States it destroys no less than 106,000 lives every year. This means, in all countries, not less than 2,120,000. Infancy, manhood, old age are alike its victims.

The disease, though always essentially the same, yet comes in different forms. Though in every case caused by a microbe, the microbe varies according to the form of the disease. Each variety of the disease is caused by a corresponding variety of the microbe.

One form of the disease is called croupous pneumonia. In the lung it acts somewhat like croup in the throat. First, the lining membranes are inflamed. Second, the lung fills. Third, the lung becomes more or less solid. Fourth, pus forms in the lung. If the disease is not arrested before the fourth, or even the third state, it is almost sure to prove fatal.

The microbe which causes this form of the disease is represented in Fig. 76. In shape it is oval, with ends rounded. Sometimes pointed. In its longer diameter it is the one twenty-five thou-

sandth part of an inch. Considerably less in its shorter diameter. It propagates by the production of spores. Sometimes the germs are seen in pairs, each pair surrounded by a capsule.

A second form of the disease is named catarrhal pneumonia. It is to the lung something like catarrh to the nasal organs. The bronchial tubes and the air cells of the lung are inflamed. Excretions are abundant. The air passages are congested — sometimes closed. This last means death.

The germ that causes this second form is similar to that of the first — similar in size, and shape, and propagates in the same way. But it differs from the first in forming itself into chains as represented in Fig. 77.

Two other forms are called septic pneumonias. They are caused by microbes which produce at once septic, or putrid, conditions in the lung. Sometimes they enter the lung by way of the air passages. At other times they come to the lung directly from some boil, carbuncle, or other suppurating wound, on the surface of the body. In the pus of such a wound are millions of the germs. By the circulation of the blood from the wound to the lung the germs are liable to be carried to that organ. When this is the case, they set up the same conditions in the lung which they set up in the wound whence they come. It is simply transferring, by the bloodstream, the disease at the surface to the lung. First, inflammation in the lung,

then the formation of pus. Bloodpoisoning may quickly follow. The patient is dead.

This terrible foe is seen in Fig. 78. It is rod-shaped, and multiplies by Fission.

But whatever form the disease takes, it is practically the same thing. When it attacks simply one lobe of a lung, it is lobar pneumonia. When it involves the whole of one lung, and this only, it is single pneumonia. When it involves both lungs, it is double pneumonia.

In all kinds of the disease, its symptoms are substantially the same,—chills, fever, headache, hacking cough, rapid breathing. In normal breathing one has about seventeen respirations per minute. In pneumonia the patient has from twenty to sixty respirations per minute.

With the appearance of these symptoms, one may know that he has pneumonia. The germs are already in the lung, doing their deadly work. They subsist on certain substances in that organ, grow, and multiply in great numbers. If septic germs, each one may become in twenty-four hours, 16,500,000. By their life processes they generate the fatal poison. This poison enters the circulation, produces the disease.

As the germs multiply with great rapidity, the poison is generated correspondingly fast. This explains why the disease frequently terminates so suddenly.

In the face of this dreadful foe, continually mak-

ing its attack in all its different forms everywhere in the world, and yearly carrying millions to the grave, the world is anxiously waiting for the discovery of two things:

First, an antitoxine which shall cure the disease. Counteract the poison generated by the germs of pneumonia, and the patient will recover. Only a question of time when that antidote will be at hand. Timely and rightly administered, it will surely conquer the foe.

Second, and better still, a vaccine which will prevent the disease. A vaccine which shall be to pneumonia what vaccination now is to smallpox. Every one inoculated will be immune. Universally used, the world will be safe.

Sooner or later, these two discoveries will be made. The world will then breathe easier. The sick will be cured. The well will be made immune. The disease will be stamped out.

Meanwhile, when one is taken with pneumonia, the very best thing, no doubt, is simply good nursing. At the very onset of the disease, put the patient in bed. Keep warm. Apply to the lungs and chest hot cloths. Wring them out of hot water—hot as the patient can bear. Cover with flannel. Change every ten minutes. Continue the treatment six hours. If the patient is relieved, continue until out of danger.

If the patient is not relieved at the end of the time mentioned, apply to the lungs mustard or flaxseed poultices.

These counter-irritants lessen the irritation within the lungs, and thus assist the patient in fighting the foe. The object is to tide the patient over the danger period. The germs ere long are poisoned to death by the very poison which they generate. If the patient can hold out until this point is reached, his hopes of recovery are great.

But, under all circumstances, avoid drugs. If taken, they only lessen the chances of conquering the disease.

Still better, try to prevent the disease. It is contagious. Quarantine every patient. Take good care of your health. Pneumonia is not unfrequently complicated with other diseases. Avoid these diseases. Sound and vigorous health is, at present, the best known preventive.

One thing more; rid your house of mice. There are good reasons for believing that the house mouse is one means of spreading this disease. It dies with pneumonia. The carcase may be left in some nook or corner. It is filled with germs. These may be communicated in various ways to persons in the house. Exterminate this rodent. It has no business in your house anyway.

PART II

FEVER MICROBES

CHAPTER XLIV

THE MICROBE OF TYPHOID FEVER

IN Fig. 79 is shown this microbe. It is rod-shaped, with the ends slightly oval. Its average length is about the $\frac{1}{500}$ part of an inch; its thickness somewhat more. It has flagella on its sides, or threadlike appendages which serve as means of motion, like fins to the fish and wings to the bird. The little rods reproduce themselves by growing a trifle longer, then dividing in the middle. This process may be kept up indefinitely.

Every case of typhoid fever in the world is caused by this microbe, and by this microbe only. The germ lives in water outside the body. Almost always the person is infected by drinking the tainted water. In this way the germ gets into the stomach. From the stomach into the bowel. Here is its natural nexus. Here it finds its proper food. Here it grows. Here it multiplies in great numbers. In growing and multiplying, it produces the typhoid poison. This poison enters the circulation and permeates the entire system.

The period of incubation,—the time from the moment of infection to the onset of the disease,—is about a dozen days. The disease is then well pronounced. All its conditions and symptoms are present,—chills and fever, headache, ache all over, high temperature, quickened pulse, diarrheal discharges.

If the patient continues to live, the fever runs about twenty-one days. Then the turning point. The fever leaves. The patient is low. The pulse is low. It is the critical moment. Give stimulants in small doses. Easily digested food,—liquid is the best,—little at a time, but frequently. As the patient becomes more and more convalescent, the appetite is keen and keener. But be cautious. Feed moderately. Over-feeding or taking cold is apt to bring on a relapse which is almost always fatal. Do not hurry about getting well. Take time.

From beginning to end, kind and skillful nursing is the main thing. It may be well to consult the up-to-date physician. But all drastic drugs are out of order. Avoid them. They do only harm.

In the United States from this disease occur about 50,000 deaths every year. Pro-rata throughout the world, 937,500 deaths annually.

Yet typhoid fever is plainly preventable. In every case, with sufficient insight and foresight, the cause might be removed, and of course the disease prevented. In every case the germ comes from

some previous patient. The germ is never communicated by the breath or by the sputum,—only by the excreta. Therefore could the excreta in every case be promptly disinfected, all germs would be killed, and the spread of the disease prevented.

But, to say nothing of lazy people, professional nurses and doctors are apt to be careless and negligent. Under their direction, without disinfection, the excreta find their way, in cities, to the sewer. Sewer gas, therefore, always contains the germs. Occasionally the disease is traced to this gas.

A family leaves its city home for a vacation in the country. During the long absence the house is vacant. No water for the sewer. The water seal of the sewer trap evaporates. The trap is dry. Through it the sewer gas comes freely into the house. With it come the typhoid germs. On the return of the family, one or more members become infected with the germs and have the disease.

But how easily prevented. On leaving the house open a faucet slightly. While absent, let the small stream of water from this faucet continually flush the sewer pipe. The water seal of the trap is thus kept perfect. No sewer gas enters the house. No germs. The fever is avoided.

But nearly, if not quite, all other cases come from water supplies. Surface water, as ponds, lakes, streams, instead of Spring water. Of course Springs may be polluted with typhoid germs; but they rarely, if ever, are. It is usually, if not al-

ways, Surface water. This is shown by authentic facts like the following:

A single soldier, in a barrack situated on a certain stream, has the typhoid fever. Twenty-eight miles below the barrack is a hospital supplied with water from the stream. By using the water forty persons in the hospital take the fever.

On another stream is a case of the fever. Twenty-five miles below, water is taken from the stream to supply a village. In that village 150 persons are stricken with the fever.

The operatives in a mill use a water closet over a brook. One of the operatives has the typhoid fever. Seven miles below the mill, a milkman washes his cans in the water of that brook. In every family using that milk the fever breaks out, — fifty families, 146 victims.

A single patient dies with the fever in a farmhouse near a brook. The contents of the water closet, into which the excreta are deposited, are spread on a field adjoining the brook. In the village below, which takes its water supply from that stream, 2035 people have the fever; 104 die.

In Syracuse, N. Y., after a severe drouth, falls a heavy shower. Surface water finds its way into a certain well. In every family using water from this well the typhoid fever breaks out. Seventeen cases prove fatal.

In a part of Springfield, Mass., typhoid fever becomes epidemic. The Board of Health trace every case to a certain milk route. Specimens of

the milk reveal typhoid germs. The cows drink from a certain brook. Specimens of that brook water reveal the same germs. The foe is thus traced to the polluted water.

Such facts might be indefinitely multiplied. They all tell the same story. In every case the enemy lurks in Surface water.

The only remedy is to prevent pollution of the water, or to stop using it. In every case of typhoid destroy the germs in the excreta. In no case dispose of the excreta where the germs may find their way into a stream. Often inspect such water supply. Send specimens to the laboratory. If germs are found, stop using it until their source is searched out and the water purified.

Look out as sharply for the ice supply. Freezing does not kill the typhoid germs. If ice is taken from polluted water, it contains the germs. When it melts, they are as active as ever.

The antitoxine for typhoid has not yet been discovered; but, what is far better, the vaccine has been discovered. In so far as used, the result is considered very successful. It probably will never be used except by those who may be specially exposed to typhoid infection. Soldiers are such a class. Owing to the fact that they generally get their drinking water, especially when on the march or in active service, from almost any source where they happen to find it, they are, more than others, exposed to infection.

For this reason the newly discovered vaccine has

as yet been tried, for the most part, on soldiers. Including all countries, not less than 150,000 have already been inoculated. Among the vaccinated typhoid has been reduced about 90 per cent. The deaths still more. In comparatively few cases of failure the fault may be owing to imperfect vaccination. When the vaccine is good, and the job is skillfully and perfectly done, every case may be a success.

Probably, in the near future, not only among soldiers, but in any neighborhood where a special typhoid epidemic breaks out, the vaccine will be generally used.

Meanwhile, there should be no relaxation in other modes of prevention.

CHAPTER XLV

THE MICROBE OF SCARLET FEVER

SCARLET fever is the child's disease. Adults may and do have it, but it prevails so much more among children that it may properly be called a disease of childhood.

The disease is caused by an exceedingly minute microbe. This tiny being floats in the air on particles of dust, or otherwise, and is therefore all the more infectious. Infection may take place not only by the usual modes of contact, but also by breathing the tainted air.

Once in the system, the germ multiplies in great numbers, and generates the poison peculiar to this fever. This poison quickly permeates the entire system. Within four days comes the onset of the disease. All its symptoms are well pronounced; — headache, sore throat, vomiting, fever. Scarlet eruptions appear the second day, — first on the breast, then over the entire body.

As the patient becomes convalescent, fine scales form and cleave from the eruptions. These scales contain thousands, perhaps millions, of germs, and are a ready, special means of spreading the disease. But the patient may communicate the disease to others at any moment from the time it begins until the scaling entirely disappears.

The fever comes in two forms, the milder and the more severe. These are, no doubt, attributable to two varieties of the microbe,—the one causing the milder, the other the more virulent. The milder form scarcely ever proves fatal; the severer proves fatal in more than a third of the cases. Death frequently comes suddenly. The patient may be seemingly comfortable to within an hour of death.

Scarlet fever, therefore, in any case is frightful. No one knows what an hour may bring forth. At the onset a doctor should be called to watch the progress of the disease. He may notice what others do not. If up-to-date, he will offer no drastic drugs, but only advise in regard to the general nursing and care of the case. He cannot administer a cure because the antitoxine to counteract the scarlet fever poison has not yet been discovered. This cure is the hope of the future. When it comes, the physician will be armed with a weapon with which to defeat the foe, and to enable the patient, it is hoped, in every case to recover.

Until then, and afterwards too, prevention should be the watchword. Rigidly quarantine every case. Let no one but doctor and nurse enter the sickroom. Disinfect and kill all germs as promptly as possible. The germs have great vitality. They may live in furniture, clothing, or other lurking places for years. Kill them on the spot.

Scarlet fever is frequently communicated by in-

fected food, milk, water. Such sources should be specially guarded. An epidemic of this disease is this moment sweeping over Boston. Over 300 cases are already reported. The Board of Health has traced the disease to a certain milk route, and ordered all milk on that route, the cans and other utensils, sterilized before distributing another drop of the milk.

This route includes 2,000 families. The milk is gathered from farms in Massachusetts and some adjoining states. It may therefore be impracticable to trace the disease to the one original point whence it started. But no doubt that one point is a single case of scarlet fever in a certain farmhouse on a farm whence some of the milk was gathered. The patient was not thoroughly quarantined,—perhaps not quarantined at all. Through ignorance or carelessness, or both, the germs found their way to the milk cans, the water in which the cans were washed; or the water from which the cows drink. The milk gathered from this farm thus became infected. It was delivered with other milk on the route. Hence the Boston epidemic.

Had that single case of the fever been properly quarantined, and the germs destroyed, all harm to the Boston consumers would have been avoided.

Beware! Draw the protective curtain about every individual case. **KILL THE GERMS!!**

CHAPTER XLVI

THE MICROBE OF MALARIAL FEVER

ABOUT 25,000 deaths occur in the United States every year from malarial fever. The disease prevails more in the South than in the North. Generally, whether in the North or in the South, on lowlands, near swamps and marshes.

The disease has distinct stages. First, a chill. Second, fever. Third, sweating. Fourth, a quiet time. These stages may come every day, every second day, every third day, or every fourth day.

This fever, in every case, is caused by a tiny microbe. This microbe is an animal. A few of the disease producing germs belong to the animal kingdom, and the malarial germ is one of them.

This animal microbe multiplies by the production of spores. Once in the system and the circulation, the germ grows and reproduces itself in great numbers. By their life processes these beings generate the malarial poison. This poison then permeates the entire system and produces the malarial fever in all its states — chills, fever, sweating.

The peculiar thing about it is, in growing and multiplying, these exceedingly minute animals fasten themselves upon the red corpuscles of the

FIG. 80.

FIG. 81.

FIG. 82.

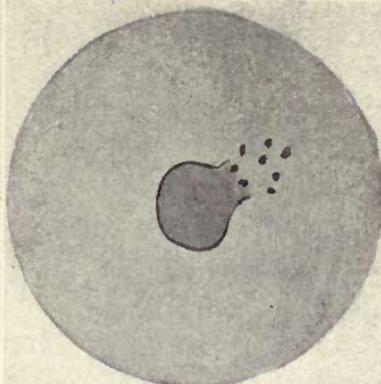
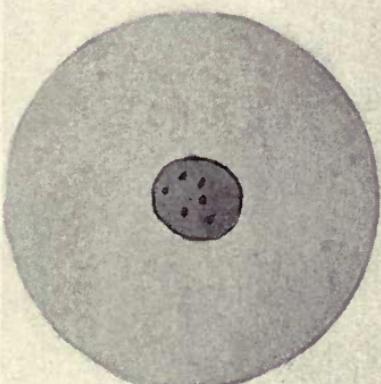
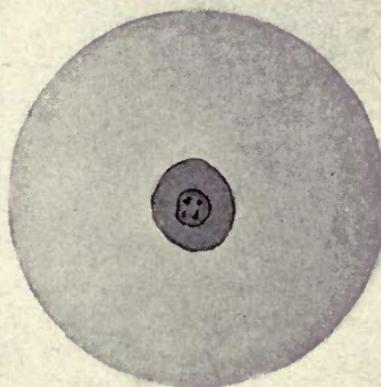
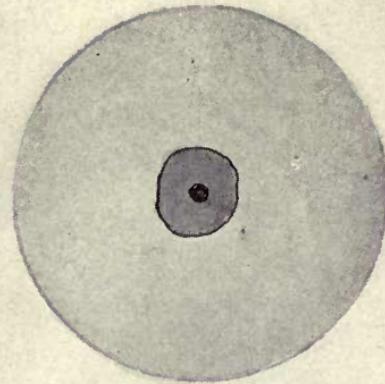
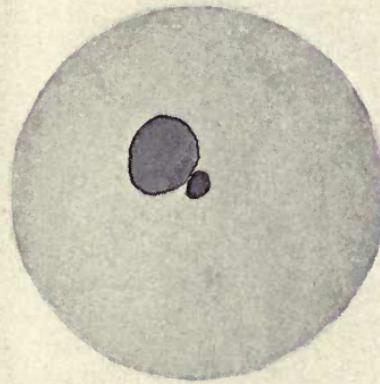
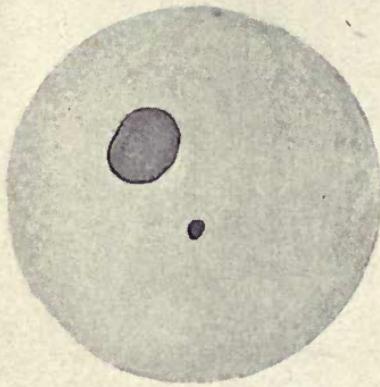


FIG. 83.

FIG. 84.

FIG. 85.

blood,—thriving, growing, multiplying at the expense of the corpuscles, consuming them as food. In Fig. 80 is seen a single malarial microbe, and a single red corpuscle. The microbe is much smaller than the corpuscle. In Fig. 81 the microbe has fastened itself upon the corpuscle.

In Fig. 82 the microbe has buried itself within the corpuscle and has begun to grow, making the whole seem larger. In Fig. 83 the microbe has commenced the production of spores. In Fig. 84 the spores are fully grown. In Fig. 85 the spores have escaped.

These spores now grow into new microbes, fasten on other corpuscles, grow and produce a new flock of spores. These new spores grow and fasten on new corpuscles, and produce another crop as before. In every case of malarial fever this process continues so long as the disease lasts.

In many cases this fever is very light. In other cases it is severe, often proving fatal. This may be explained in either of two ways. On the one hand, the attacking microbes may be more than usually virulent, and, in their life processes, generate a more virulent poison. This makes the disease severer. At other times, the microbes may be a milder variety, generate a milder poison, and cause only a milder disease.

On the other hand, the blood of the average adult contains about 33,750,000,000,000 red corpuscles. In all forms of the malarial fever the infecting microbes multiply into millions upon millions. These

multimillions attack multimillions of the corpuscles. Then, by their life processes, they produce the poison which causes the disease. But sometimes the infecting germs, owing to relatively more favorable circumstances, multiply into relatively greater numbers. These greater numbers attack correspondingly greater numbers of the corpuscles. The result is a relatively greater amount of the same kind of poison. This poison, as a whole, causes a relatively more fearful and fatal form of the disease. At other times, the infecting germs, owing to relatively less favorable circumstances, propagate into relatively less numbers, attack correspondingly less corpuscles, generate a relatively less quantity of the poison, which of course results in the milder form of the disease.

But why do the paroxysms of this disease,—whether in the mild or the severe form,—come, sometimes every day, sometimes every other day, at other times every third day, still other times every fourth day? Simply owing to the fact that the paroxysms come at the exact moment when the germ sacs burst and the spores are born; coupled with the other fact that there are four varieties of the infecting germs, each a variety of the same species,—and each variety requires its own time for sporulation. The first variety after infection, sporulates every twenty-four hours; therefore the patient, infected by this germ, has the chill, fever and sweating every day. The second variety produces spores only

once in two days; therefore the patient, infected by this germ, has the paroxysms only every other day. The third variety requires three days to produce its spores; therefore, to the person infected by this germ, the paroxysms come every third day. So, the fourth variety requiring four days to grow and ripen its spores, the person, infected by this variety, has the chill, fever and sweating every fourth day. In every case the paroxysms begin at the time the new spores escape into the blood.

But the most practical of all practical things relative to malarial fever is how to treat it. Two modes are at hand. One is to cure it. Quinine is the natural antitoxine. When coming in contact with the malarial poison generated by the germs, it neutralizes that poison, and the patient recovers. The dose to give varies according to the patient. Consult a skillful physician. He will adjust the dose to the patient. Administer it about four hours before the expected return of the paroxysm. The quinine will thus get into the circulation; and, as the microbes in growing and getting ready to sporulate, throw off their poison, this antidote, already in the blood, will counteract and destroy that poison, and thus prevent the fever, chill and sweating. By commencing this mode of treatment early enough, and continuing it persistently, it is believed nearly all cases of malarial fever may be cured.

But the other and best mode is to prevent the disease. In every case of malarial fever infection

is caused by the bite of a mosquito. That mosquito is the *Anopheles*. Its habits are nocturnal; it does its mischief by night. Seek protection against this foe.

First, protect those sick with the fever. The mosquito cannot infect the well until it has bitten the sick. Inserting its proboscis through the skin of the patient, it draws blood, and with the blood, germs into its proboscis and stomach. Then, and only then, biting a well person, that person is infected by the germs. Protect the sick. Keep every mosquito from the patient's room.

Then protect the well. In localities where the mosquitoes abound, screen the doors, windows, beds. Keep the foe from you.

Yet the best way to protect, is to exterminate the mosquitoes. They abound in swamps, marshes and lowlands. Hence, in such localities the fever prevails. Dry up these places. In the stagnant pools mosquitoes lay their eggs, hatch their larva, and thus produce new swarms of the pest. Drain the swamps, marshes, lowlands. Spray them with kerosene. This kills the larvæ and the mosquitoes, too. Dry up these breeding places. Plow them. Cultivate them. On them raise bountiful crops.

Several states have made war against the common foe along this line, and with signal success. Continue the war until the last foe expires. Drive the malarial poisoner from the world, and malarial fever will be no more.

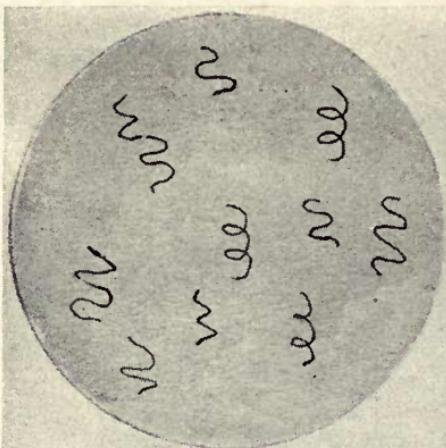


FIG. 86.

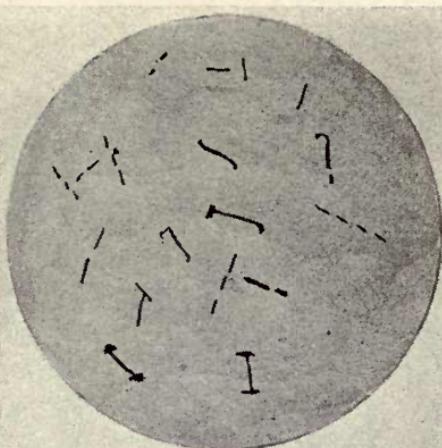


FIG. 87.

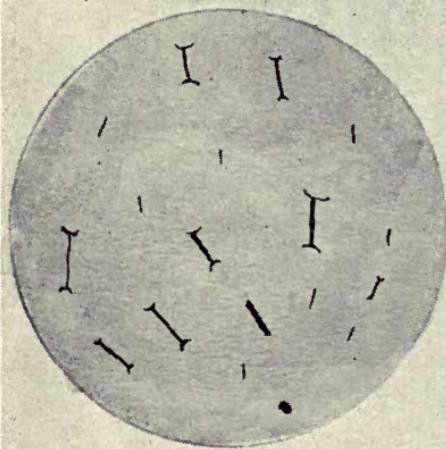


FIG. 88.

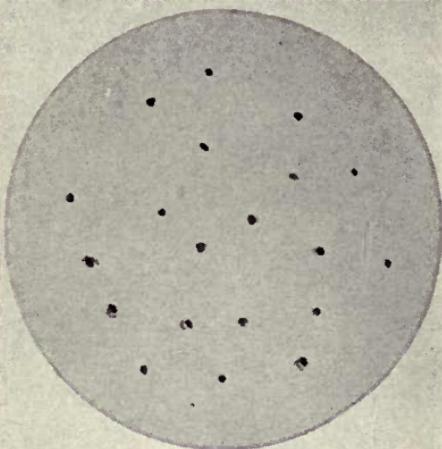


FIG. 89.

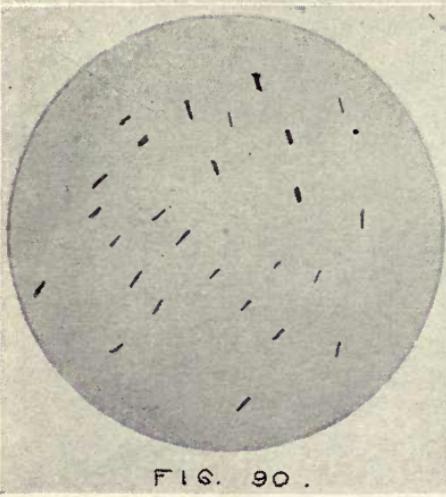


FIG. 90.

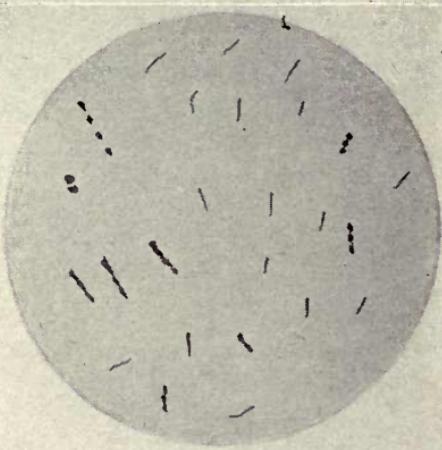


FIG. 91.

CHAPTER XLVII

THE MICROBE OF RELAPSING FEVER

IN about seven days after infection, comes the onset of this disease. The temperature suddenly rises, with all the attendant symptoms of the fever. In this state the patient continues seven days. Then the fever leaves, and the temperature suddenly drops to normal. In this quiet condition the patient remains seven days. Then there is a relapse. The temperature again suddenly rises, the pulse is quickened, with all the other symptoms of the fever. This continues, as before, another seven days. Then the fever leaves, the temperature drops again to normal — the quiet stage is on as before. In the same way there may be two or three more relapses.

The microbe that causes this fever is represented in Fig. 86. It belongs in the Spiral type. Its winding threads are about the $\frac{1}{7500}$ part of an inch in thickness — many times that in length. It is exceedingly active — in motion all the time, as if it were an animal.

The incubation period of this germ is seven days, corresponding to the relapsing time of the fever. Seven days after infection, the fever begins. During the next seven days, while the fever lasts, every

drop of the patient's blood contains a large number of the germs. By their life processes the germs generate the poison which produces the fever. At the end of the seven days, when the fever disappears and the pulse drops to normal, not one microbe is found in the blood. They all have retired to the spleen. That organ is full of them. Here they remain seven days to produce their spores. The parent microbes are apparently sacrificed,—sacrificed to beget their young in the form of spores. At the end of the seven days, the spores enter the circulation where they speedily become adult microbes. The blood is again full of them, with the relapse of the fever. This dual process of seven days in the blood and seven in the spleen, continues until the end of the disease.

After spending six months in the Sunny South, migratory birds migrate to the North for nesting and rearing their young. After six months here, young and old, if any, migrate back to the South. Then, in six months, again to the North. So on continually.

Microbes of the relapsing fever, after spending seven days in the blood, migrate to the spleen for nesting and rearing their spores. At the end of seven days here, in their renewed form, they migrate back to the blood. Then again to the spleen, and so on, to the end of the disease.

In the near future, it is hoped, an antitoxine will be discovered to cure this disease. Meanwhile, good nursing is the best, if not the only, remedy. At its

onset, a doctor should be called to watch the course of the disease, and to give counsel accordingly.

This fever is contagious and infectious. Rigidly quarantine every patient. Thoroughly disinfect before the quarantine is raised.

CHAPTER XLVIII

THE MICROBE OF TYPHUS FEVER

THIS microbe is a bad one. It is represented in Fig. 87. It is the cause of a bad fever. Typhus is among the worst. Its onset is marked by quickened pulse, high fever, much thirst, nausea, vomiting.

This fever comes, sometimes in a mild, sometimes in a severe form, and lasts from fourteen days to six weeks. The two forms are, no doubt, caused by two varieties of the same species of germs. In the milder form the patient may have some red eruptions on the face around the mouth, and, on the fourth or fifth day, a refreshing sweat, which seems to diminish and clear up the fever. In the severe form the patient has dark spots on parts of the body, distended abdomen, and diarrhea with bloody discharges. From the milder form the patient usually recovers; the severe form most always proves fatal.

This fever is exceedingly contagious and infectious. The germ is communicated from the patient in all the usual ways,— by contact, clothing, furniture, pet cats and dogs, flies, water, food, and breathing infected air. When the most rigid precautions are not taken, therefore, a single case may result in an epidemic.

This disease will take its natural course, resulting in recovery or death, according to circumstances. Not wise to attempt to check it, after once on. Let it take its course; but provide the very best nursing.

The microbe which causes this fever must be closely related to the germs of putrefaction, because the disease has putrefactive tendencies. See to it, therefore, that the patient's room is thoroughly ventilated and kept perfectly clean, with the free use of disinfectants.

But by all means prevent the disease from spreading by thorough quarantine. Except attendants, no one to enter. At the termination of the disease, disinfect bedding, clothing, the whole house.

CHAPTER XLIX

THE MICROBE OF SPLENIC FEVER

THIS is a disease both of the lower and the human animal. It originates with the lower animals, and from them is communicated to Man. Therefore, when it prevails among sheep, cattle, horses, it is liable to become epidemic among the people.

The blood of the animal or person having this disease turns dark, and dark spots,—frequently coal black in the center,—appear on the surface of the body. For this reason the disease has been called anthrax, because this word comes from a Greek word which means a coal, or a black substance.

The disease also greatly affects the spleen. This organ becomes congested, swollen to twice or three times its normal size, with high fever. The disease is therefore also known as splenetic fever.

The microbe that causes this fever is represented in Fig. 88. It belongs in the Rod-shaped type. The little rods are cup shaped at the ends. Their shorter diameter is about the $\frac{1}{1000}$ part of an inch; their longer diameter much more. They propagate by the Production of Spores.

To the lower animals the fever comes in two forms. One is the acute form. By swallowing

with the food, or breathing, the germs the animal becomes infected. The germs find their way into the blood. Here they thrive, grow, produce spores, multiplying with great rapidity. The fatal poison is generated in the blood correspondingly fast.

All this is done quickly. As the amount of poison attains a certain degree, the animal suddenly drops; the pulse and the breathing are more rapid; there is a struggle; the animal is dead.

The other form is more prolonged. The pulse is quickened; the breathing is hurried; there is bleeding at the nose; the excreta are tinged with blood. In one day, or in several, the animal is dead.

Human beings take the disease in either of two ways. First, by breathing or swallowing the germs. The minute germs, scattered by infected flocks or herds, rise on particles of dust, and are breathed by workmen among the animals. Or water, tainted by the germs, may be used as drink by the workmen. After infection, the symptoms may appear in a few hours, or not till as many days,—fever, headache, chills, sickness. In this form of the disease, if fatal, death comes in from two to eight days.

In the other form of the disease, the germs are introduced to the circulation by working on infected wool or hides, through some scratch on the hands or forearms. Infected in this way, the disease develops rapidly. On the surface of the body quickly come inflammatory eruptions, carbuncles,

malignant pustules. The patient endures great suffering. Death is almost certain.

The chief, if not the only, remedy for this disease, is prevention. As it always comes from the lower animals, prevent it among them, and it disappears from the world.

Happily, a vaccine for the inoculation of the lower animals has already been discovered and largely applied in Europe, where the disease has chiefly prevailed. Before this discovery, about ten per cent. of all the sheep, and five per cent. of all the cattle, died yearly with this disease. Since its discovery, the fatality has been reduced to less than one half of one per cent.

Among human beings, therefore, this disease is now practically exterminated. This shows what great hope there is for the world in the future discovery of vaccines which shall prevent other diseases.

CHAPTER L

THE MICROBE OF CEREBRO-SPINAL FEVER

THIS disease, as implied by the name, is a fever which affects the brain and the spinal column. The microbe which causes it in some way enters the circulation, finds its way to the membranes covering the brain and the spinal cord. Here it finds its natural food. Here it grows. Here it quickly multiplies into a multitude of infinitely small beings. By their life processes these beings generate the fever poison. This poison enters the circulation, permeates the entire system, and does its terrible work.

The onset of the disease is sudden and sharp. The poison at once inflames the membranes of the brain and spine. These are known as meningen membranes; hence their inflammation is cerebro-spinal meningitis. With this come chills, high temperature, quick pulse, headache, vomiting and delirium.

The disease is as fatal as it is violent. In its milder form, two out of every ten die; in its severer form, seventy out of every hundred. Including inflammation of the brain — which is another species of this disease — about 30,000 die of it in the United States every year.

The disease prevails chiefly among children. After the child is taken, the crisis may come in two, or in eight, days. If the child lives, recovery is slow and tedious, frequently requiring weeks. It sometimes happens that a physical wreck is the result.

About the only thing which can be done for the patient is to administer the very best nursing. Drugs will only harm. But call the most skillful physician at hand, to watch the progress of the disease, and to give counsel.

The discovery of the right antitoxine for this fever would be a great boon to the world. Meanwhile, remember the disease is contagious and infectious. Closely quarantine. Keep everything sanitary. Freely use disinfectants in the patient's room. As soon as the disease terminates, thoroughly disinfect bedding, furniture, clothing, room, — the entire house.

CHAPTER LI

THE MICROBE OF PUERPERAL FEVER

THE method by which Nature perpetuates life on the earth, considered in itself alone, is not dangerous to life. On the contrary, it naturally gives larger and better volume to life. In developing the life of the child the mother herself receives new development, becoming stronger in body and mind.

This is the general rule. The chief exception comes from puerperal fever with its fatal results, — a fever confined exclusively to childbirth. By this fever in the United States about 10,000 mothers, in adding as many new lives to the Republic, sacrifice their own lives every year. At this rate throughout the world, the yearly sacrifice is about 170,000.

The microbe that causes all this slaughter is represented in Fig. 89. It belongs in the Spherical Type, and is exceptionally small — only the $\frac{1}{25000}$ part of an inch in diameter. The drop of water that is the $\frac{1}{25}$ part of an inch in diameter is comparatively small. But how many of the microbes which cause the puerperal fever may be packed in the space occupied by the drop? The two spheres are to each other as the cubes of their diameters. The cube of $\frac{1}{25}$ is $\frac{1}{15625}$. The cube of $\frac{1}{25000}$ is

This germ is a native of garden soil. In that state it is not only harmless but may even perform some good service. But when, by some wound, this germ is introduced to the circulation of a predisposed person, its mischief may be something terrible.

Now, at childbirth, the mother is in a peculiarly predisposed condition. Infected at that moment, the germ multiplies with great rapidity, and, by its life processes, generates the fatal poison. Blood poisoning, as the result, is sure, quick and complete. Usually by the third day the mother is sacrificed.

What will you do? Cure the disease? With the right antitoxine, it might be cured. Without it, never! But one thing you can do, and do easily — prevent the disease. No disease is more easily prevented. Simply sterilize — that's all. Sterilize room, bed, clothing. Sterilize all the material, utensils, — everything used. Sterilize nurse, — clothing, hands. Especially sterilize doctor — clothing, hands.

How simple! A trifle of bichloride of mercury, or of carbon dioxide, properly diluted with water, sprayed on room and everything that enters — all

is safe! The germ that kills is itself killed. The mother lives!

In every case of childbirth, a few minutes' work of this kind — and no more puerperal fever in the world. One hundred seventy thousand mothers snatched from death!

Think of it. Remember it. Tell it to your neighbors. Especially tell it to your doctor! In nine cases out of ten, he is the responsible party! In nine cases out of ten he carries the deadly germ from house to house, from bed to bed. Ignorant, or careless, or both. Wake him up. Open his eyes. Keep them open.

Sixty years ago, before the germ theory was known, amid the jeers and ridicule of the older physicians, Oliver Wendell Holmes told the world that doctors carry the puerperal fever on their hands and in their clothing from bed to bed. The author of the "Autocrat at The Breakfast Table" lived a hundred years ahead of his times. The world is not up to him yet. But it is coming. Let it come!

CHAPTER LII

THE MICROBE OF RHEUMATIC FEVER

THIS is a comparatively rare disease. As a rule, neither children nor old persons have it. Persons between the ages of twenty and forty are chiefly addicted to it.

Whenever occurring, this fever is caused by a micro-organism. But this microbe seems to be, comparatively, little known — probably for two reasons. First, because the disease is so rare. Second, because the disease is so uniformly mild. The patient most always recovers.

But the disease, while it lasts, is exceedingly troublesome. The germ is a native of the soil. Infection is made possible by some scratch or little wound, usually on the hands. By certain means the germ finds its way into this wound. Here it finds food, grows, multiplies, and generates the poison which causes the disease. Chills, fever, sweating follow in rapid succession. The joints become inflamed and painful. Perhaps the most annoying thing is the exceeding sensitiveness of the muscles; the patient cannot bear to be moved, or even touched. Any disturbance is painful.

All this is accompanied with a feeling of exhaustion and general prostration.

The fever may run from thirteen to twenty-one days. Attention and tender nursing are usually the only services required. Keep the patient in bed. Use only flannel,— flannel robes, blankets. Easily digested diet, with plenty of cold water at all times.

Remember the patient is in a condition which renders him peculiarly predisposed to other diseases. Therefore look out for complications. Use disinfectants freely. No visitors allowed. Avoid the doctor, if possible. He visits other patients with contagious and infectious diseases. From them he may bring germs. If called at all, require that his clothing and hands be sterilized before entering the patient's room. Impertinence, if necessary, is better than to run risk.

Above all, be patient yourself, and your patient will recover in due time. Not until two or three weeks after recovery should the patient engage in active business. The heart has been sorely tried; needs rest for regaining former strength before excitement.

CHAPTER LIII

MICROBE OF THE DENGUE FEVER

THIS fever is decidedly tropical; it appears only in the South. The microbe that causes it is also tropical; it can live only in the South.

The disease is generally, if not always, epidemic. In the hot summer weather it breaks out suddenly, spreads rapidly, is soon over.

Intense headache, nausea, vomiting, with red rash, are its symptoms. The full onset comes suddenly, rages like a wild fire about three days. There is then a lull about the same time. The symptoms then return, lasting a couple of days more. In all about eight days.

Good nursing is the best treatment. Adults in good health always recover. With young children and extreme age, this fever often proves fatal.

The disease is exceedingly contagious and infectious.

The best remedy is prevention. Rigidly quarantine every case. Thoroughly disinfect,—destroy all the germs.

CHAPTER LIV

THE MICROBE OF YELLOW FEVER

THIS microbe is represented in Fig. 90. It is Rod-shaped and is one of the smallest pathogenic germs. When isolated, it was named bacillus icteroides.

This microbe belongs in the animal kingdom. On its tiny body are several fine thread-like appendages by which, no doubt, it is assisted in moving about.

This germ, too, is tropical — it can live only in tropical climates. The first touch of frost destroys it.

The yellow fever, therefore, prevails only in tropical climates. Individual cases may be imported into the North; epidemics occur only in the South. Northerners, going South, are exceedingly predisposed to the disease, and, when infected, always have it.

Infection takes place by the bite of a mosquito which entomologists have named *Stezzomia Fasciata*. The mosquito must first bite a fever patient. In sucking blood of the patient into and through its proboscis, it draws in fever germs. Then, in biting a well person, it infects that person with the germs taken from the patient. In

this way, and in this way only, is the fever communicated from one person to another. Only in this way does the fever become epidemic.

As soon as one is infected, the germs multiply in great numbers, and generate the yellow fever poison. This poison sickens the patient, causes headache, chills, fever, nausea.

In a day or two there is a change. If for the better, the patient recovers. If not, there is a relapse. All the symptoms return with intensified severity. The skin turns yellow. There is black vomit. The patient dies.

The disease is extremely fatal. Out of every hundred cases about seventy die. In the warm countries of the South the mortality is large every year.

Fortunately, a serum has already been discovered which promises to become a true antitoxine. Timely and properly administered, it will, no doubt, greatly reduce the mortality and make this dreadful fever more endurable.

The true way, however, to treat this disease, is to prevent it. Lock the door before the horse is stolen. The habits of the murderous mosquito are nocturnal. It does its mischief by night. Screen against it. Keep the intruder at a distance. Especially screen every one sick with the fever. Prevent the mosquito from spreading the disease by carrying germs from the sick to the well.

Screen by night, and spray with kerosene by day. Spray all the breeding places of the mosquito.

Kill the larvae before they take wings and fly away.

In countries, where the fever is endemic, governments should take hold of this matter in earnest. Spare no expense. It is a wise and humane investment. It saves life!

The French undertake to construct the Panama Canal. The fever there is endemic. The workmen are imported — predisposed to the fever. They die off in great numbers. The mortality is so great, the job is abandoned.

The United States buys the whole thing from the French. The Yankees pry into the cause of the fever, compel it to yield up its secrets. They import their workmen. They protect them. They fight the mosquito to kill. They screen the workmen by night. They apply the kerosene by day. The mosquitoes die. The workmen live. The great enterprise is a success. The white man conquers the tropics by conquering *Stezzomia Fasciata*.

Make war upon the mosquito. Prevent the fever. Lock the door!

PART III

PLAQUE MICROBES

CHAPTER LV

MICROBE OF THE BUBONIC PLAGUE

As seen in Fig. 91, this microbe belongs in the Rodshaped Type. The rods are exceedingly short and thin. They are single, in pairs, in chains, and multiply by Fission. Seemingly by means of infinitely fine hairs, these tiny beings move about.

Infection occurs in three ways. First, by inoculation. The germ finds its way into some little scratch or wound on the skin. In this way it at once enters the circulation, and multiplies wonderfully fast. The disease comes on in twenty-four hours. Hardly a patient lives.

Second, by breathing the germ. The germ rises on particles of dust, and is drawn into the lungs. Infected in this way, the disease appears in two or three days, and, it is said, not a case lives.

Third, by swallowing the germ. In food or drink it is taken into the stomach. Thus infected, in about eight days comes the onset of the disease; about half of the cases recover.

In any form, therefore, the disease is something

terrible. The poison generated by the microbes is exceedingly virulent. It goes in blood streams through the system. Glands, like the armpits and groins, become inflamed and swollen. The swellings are called buboes; hence the name, bubonic plague. On the buboes scabs are formed an inch in diameter. They turn black; hence the plague was formerly called "The Black Death."

Liver, spleen, kidneys also become inflamed. Chills shake the nerves. Temperature mounts up. Fever burns like a fire. More than words can tell, the patient suffers. Death is a welcome relief.

Flies, mice, especially rats, carry the germs, spread the disease. These animals have it themselves and perish in great numbers.

In parts of Asia,—India, Persia, Bombay,—the plague is endemic. Here originating, it spreads in epidemics over Europe. From the year 1500 to the year 1840 Europe was scourged by 96 epidemics. In the fourteenth century an epidemic overspread the country, continued six years, destroyed 25,000,000 lives—one fourth of all the inhabitants in Europe.

Dense was the ignorance in regard to the plague. No one knew what it was. No one knew its cause. No one knew how it was spread. No one knew how to treat it. No one knew how to prevent or control it. In their ignorance the people were amazed, dazed, crazed, died.

But to-day what a change! Knowledge has lifted the cloud. The plague is understood. Its

cause is known. The means by which it is spread are known. How to treat the disease is known. How to prevent it is known. A vaccine has been discovered. With it thousands in India are inoculated. War is waged upon flies, mice, rats. Mortality there is reduced eighty per cent.

Recently, steamers from the old country brought the plague to San Francisco. Landing at the wharves, infected rats with their flees come ashore, invade Chinatown. The plague breaks out. But the authorities attack it right and left. They quarantine every patient. They vaccinate the exposed. They raise an army of rat-killers, mice-killers, ground squirrel-killers. For forty miles up and down the coast, they make war upon the rodents. They exterminate them. The plague is conquered.

Ignorance is death — Knowledge is life.

CHAPTER LVI

MICROBE OF THE LEPROUS PLAGUE

THIS germ belongs in the Rod-shaped Type, Fig. 92. In length it takes 10,000, in thickness 50,000, to span an inch.

Infection by this germ takes place by inoculation — in this way only, probably. Through some wound, or little abrasion of the skin, the germ enters the circulation. Once in the blood, it grows slowly. At length it divides into two parts. Each part grows and divides as before. The process is exceedingly slow.

In multiplying, the germs produce the leprous poison. Slowly the poison accumulates. In some years it brings the onset of the disease.

As the disease shows up, it may be in one of two forms. Doubtless the two forms are caused by two varieties of the same microbe — one for each form. In one form the poison affects chiefly the nervous system. It has an anæsthetic effect on the nerves, — destroys their sensitiveness, action, life. The muscles therefore become contorted, ill shapen. Eruptions appear at the surface, with ulceration. For many years a living death is the doom.

In the other form, the poison affects principally the skin. The germs work just beneath, and in, the

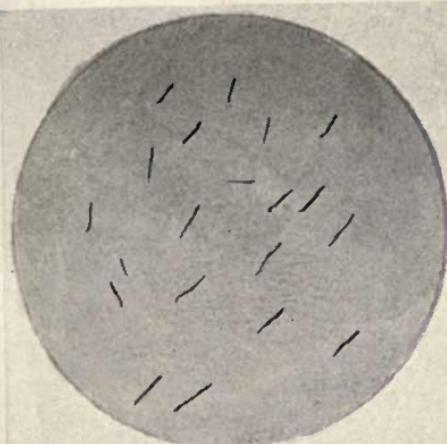


FIG. 92.

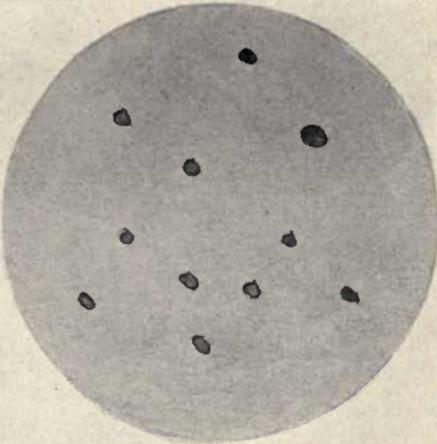


FIG. 93.

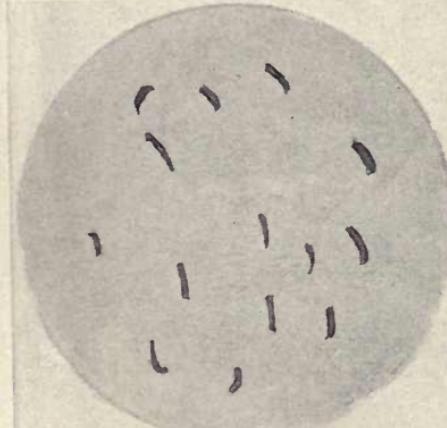


FIG. 94.

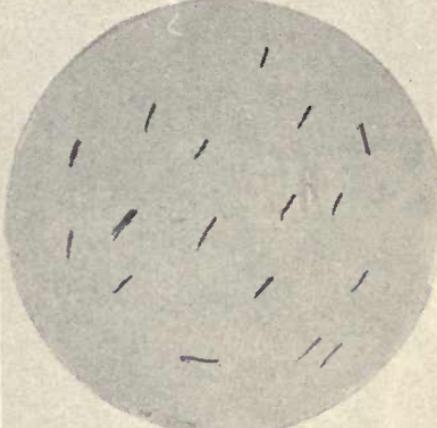


FIG. 95.

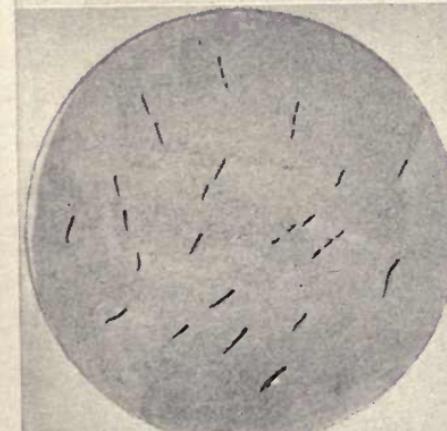


FIG. 96.

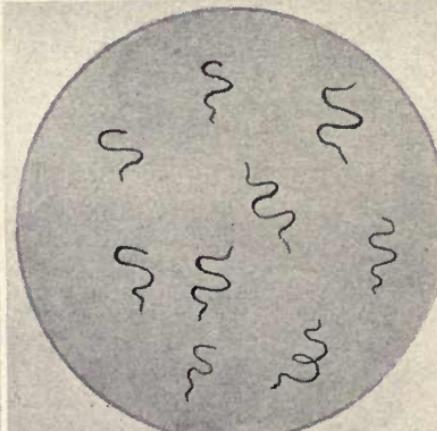


FIG. 97.

true skin. The poison breaks down the cells, forms bunches. The bunches ulcerate, form pus. This form of the disease is exceedingly loathsome. Banished from society, the victim ekes out a miserable existence of many years.

The plague is very ancient, and has appeared indifferently in all countries. Individual cases have occurred in several of the United States. "Incurable" has been the word. Yet recent investigations give promise of an antitoxine in the near future which shall cure.

Meanwhile, prevention is the rule. In some lonely spot — preferably a small island in the ocean — the pest house, with the most rigid quarantine, is the only proper place on earth for the leper.

CHAPTER LVII

MICROBE OF THE SYPHILISTIC PLAGUE

POLLUTING the source of life pollutes the whole life. The syphilistic plague does this. Beginning in the genital organs, it finally reaches and blights the entire being.

The plague has three germs, or stages. The first is Gonorrhea. It is caused by a spherical microbe. Millions of little balls work the mischief, Fig. 93.

The second is the soft sore. It is caused by a rod-shaped microbe. The poison is generated by millions of minute rods. The rods are slightly oval, Fig. 94.

The third is the syphilis proper. It is caused also by a rod-shaped microbe. Multiplying itself into millions, they generate the terrible virus, Fig. 95.

In all its forms, the disease begins in the genital organs. These are the first to suffer. The lining membranes are inflamed, with poisonous secretions as the result.

Here, by their life functions, multiplying to any extent, the germs enter the circulation, and are carried to other, or all parts, of the system; to the intestinal tract,—inflammation, ulceration are the result; to the joints,—they inflame, swell, ache; to

the muscles,—soft sore follows; to the lungs,—they are broken down; to the heart,—it forgets to beat; to the brain,—mentality is destroyed.

Thus, always beginning at the physical source of life, the disease ends in a physical wreck. Noble manhood, beautiful womanhood are no more.

This plague is contagious, and contagious only. From person to person it is communicated only by contact. Its hot-bed is the “fancy house.” The door to this den is the avenue to hell. Enter not!

CHAPTER LVIII

MICROBE OF THE SMALLPOX PLAGUE

THE microbes which cause this disease are exceedingly small rods, Fig. 96. They occur single or in chaplets.

The germ is so small that it easily floats in the air. It can hardly help it. Infection therefore occurs in the usual ways, but especially by breathing the germs.

Rolled into little balls, the germs, on the average, are about the one-fifty thousandth part of an inch in diameter. It is a tiny drop of water that measures only the one twenty-fifth of an inch in diameter.

But the two spheres are to each other as the cubes of their diameters. The cube of $\frac{1}{25}$ is $\frac{1}{15625}$. The cube of $\frac{1}{50000}$ is $\frac{1}{125000000000000}$. The former cube divided by the latter is 8,000,000,000. Therefore eight thousand millions of the microbe that causes the smallpox may be packed within the space occupied by the tiny drop.

Any wonder that this germ floats in the air? Any wonder that the disease is so "catching"? That people fear it as they fear the Devil?

In eight or ten days after one is exposed, the disease comes on in full force. Chills shake; fever

burns; head aches; back pains; face reddens; eyes become bloodshot; stomach throws up. The patient is thoroughly sick.

On the third day, red eruption appears on the forehead, lips. It is the advance guard — a day or two later come the pustules. They cover the body; they harden; they soften; they fill with pus; they scab over; they are surrounded with red rings. A strong odor is emitted.

The disease is loathsome, destructive. About one half the patients die.

As recovery begins, itching begins; scabs fall; pockmarks remain. A pitted face is henceforth the telltale.

Vaccination is now the universal preventive of the Smallpox Plague. The vaccine was discovered by Jenner a century and a quarter ago. Before the discovery, the pitted face, the world over, was the rule; the smooth face the exception. Now, the world over, the smooth face is the rule; the pitted face the exception. The doctor's vaccine has wrought the revolution. He stands in history one of the world's great benefactors. His message proclaims to the world to-day what vaccine may yet do for other diseases.

But the world takes a vicious delight in crucifying its Saviours. When Jenner announced his great discovery, he was scoffed, ridiculed, kicked!

CHAPTER LIX

MICROBE OF THE CHOLERA PLAGUE

THE microbe that causes this plague is represented in Fig. 97. It belongs in the Spiral Type. The spirals have one, two, or more turns. A fine hairlike terminal appears at one or both ends. They assist in locomotion, like the tail to the fish.

This being is infinitely small. A thousand million may occupy the space of a tiny drop of water.

The intestinal tract is the habitat where this germ works its mischief. Infection takes place by swallowing the germs in food or drink.

Once in the stomach, its work is sudden, sharp. Unusually rapid is the multiplication, powerful and quick to act is the poison. The germs stay in the tract; the poison takes the blood stream and quickly permeates the entire body.

In twenty-four hours after infection, the disease is on in full force; intense diarrhea; nausea; vomiting; fever; headache; general prostration.

Like a cyclone comes the disease; it goes as sudden. Life hangs in the balance. Little can be done to cure. True antitoxine does not yet show up. About half the cases die. Three or four days tell the story.

History declares the plague ancient. Through

the centuries has it raged. Endemic in Asia, many and many the epidemics spread over Europe. Millions upon millions by the invisible foe have been doomed to a premature grave.

The plague is yet preventable. Present knowledge conquers the foe. Rigid quarantine, vaccination, perfect cleanliness and sanitation are equal to the emergency.

Formerly, the epidemic that overspread Europe came to this country, found its way from Atlantic to Pacific.

The light of to-day prevents that repetition. The plague made its last attempt to visit this country late in the fall preceding the World's Exposition at Chicago. A steamer from Hamburg fetched cholera cases into New York Harbor. Had the plague come ashore, it would have found its way to, and broke out in, Chicago in the Spring, exploded the Exposition, scattered it to the four winds of the earth.

But that infected steamer was chained outside the harbor, quarantined, cleansed, disinfected. Not a soul on board could step a foot on shore until danger was past.

The foe was conquered. Chicago was safe. The Exposition a success! Up-to-date knowledge, timely applied, is our safety.

CHAPTER LX

MICROBE OF THE GREAT WHITE PLAGUE

CONSUMPTION, or tuberculosis, is, by all odds, the worst disease that afflicts the human race. It is called tuberculosis because it forms tubercles, or small bunches, in the lungs. These tubercles are formed out of broken down cells and tissues of the lung. By continuing to form, they finally destroy the lung. The lung is, as it were, consumed. Hence the popular name for the disease, consumption.

The disease is usually located in the lungs; but it may locate in any other parts of the body — the bones, the spine, the joints, the bowels, the brain.

Consumption is the worst disease because it destroys more lives and causes more suffering than any other disease. At least, one seventh of the human race die with consumption. The population of the earth is estimated at 1,500,000,000,— the average length of human life at forty years. Therefore every forty years 1,500,000,000 people die. One seventh of this number, or 214,285,754 die with consumption every forty years,— 5,357,142 every year; 446,428 every month; 14,880 every day; 620 every hour, 10 every minute.

Imagine a single case: The individual knows not

when the disease begins. It comes on slowly, insidiously. Little by little it steals its way, slowly making more and more inroads upon the system, until the patient knows that he stands face to face with the enemy, and has all he can do every moment to struggle for existence.

The disease lasts sometimes a longer, sometimes a shorter, time. Usually several years are required to run its course. Sometimes the individual bravely fights the foe for twenty years, or more, only to be conquered at last. Think of the suffering in this single case,—gradually wasting energies, fading hopes, disappointed ambitions, the long continued care and anxiety of loving friends, the sorrow, the final mourning.

Think of all this suffering, then multiply it by 10 for every minute; by 620 for every hour; by 14,880 for every day; by 446,428 for every month; by 5,257,142 for every year; by 218,285,714 for every forty years. The total amount of suffering in one generation is utterly incomprehensible. All the suffering caused by the ravages of war, of accidents on railways and steamships, in coal mines and by fires,—in the comparison,—dwindle into insignificance. The suffering caused by all the other great plagues,—leprosy, the bubonic plague, the syphilistic plague, smallpox, cholera,—all put together, does not begin to equal the suffering of the one Great White Plague.

All this misery, hanging from century to century, like a pall over the world, is caused by an almost

infinitely small microbe, and by this microbe only. Since the world began, not a single case of consumption has come from any other cause; so long as the world shall endure, not a single case will originate from any other source.

The microbe is represented in Fig. 98. It is named *Bacillus Tuberclæ*,— *Bacillus*, because that word means a rod, and the microbe is rod-shaped; *Tuberclæ*, because in the progress of the disease the microbes form tubercles in the lungs or other organs. Like the individuals in every other species of living beings, the individuals composing the species of microbes causing consumption, vary in size. Of all the millions generated in the lungs of a single case of this disease, scarcely any two can be said to be exactly the same in size. Their longer diameter varies from $2\frac{1}{2}$ to 5 micromillimeters. Their shorter diameter is always about one-third of the longer. But, rolled into little balls, each little sphere, on the average, would be about three and one-third micromillimeters in diameter.

To get something of an idea of the almost infinite smallness of these little beings, we may find, by a little calculation, how many of them may be packed into the space occupied by a small drop of water, the drop best explains.

The millimeter is the one twenty-fifth part of an inch. The drop of water, whose diameter is only the one twenty-fifth part of an inch, is certainly a comparatively small drop.

The micromillimeter is a thousand times less

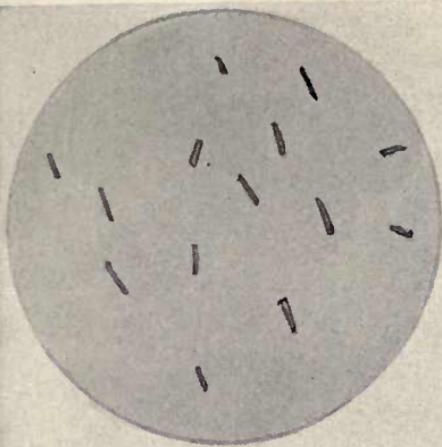


FIG. 98.

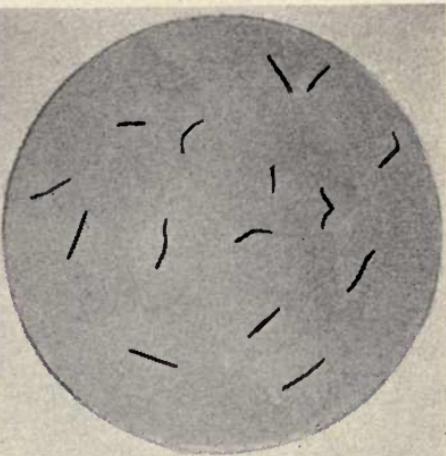


FIG. 99.

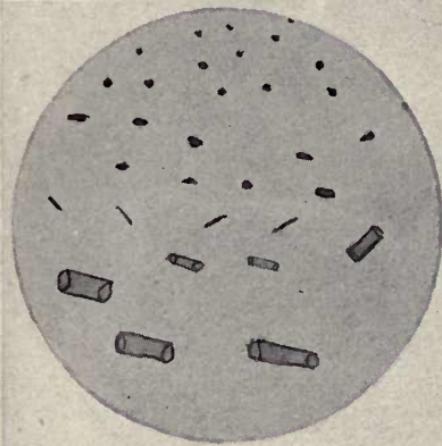


FIG. 100.

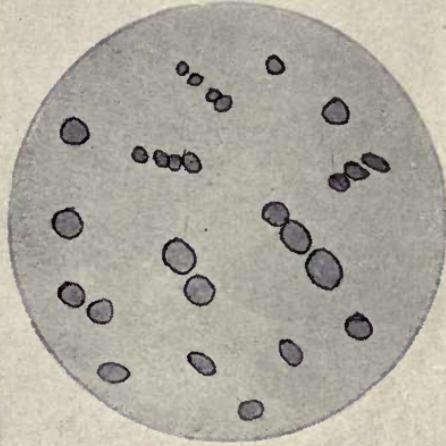


FIG. 101.

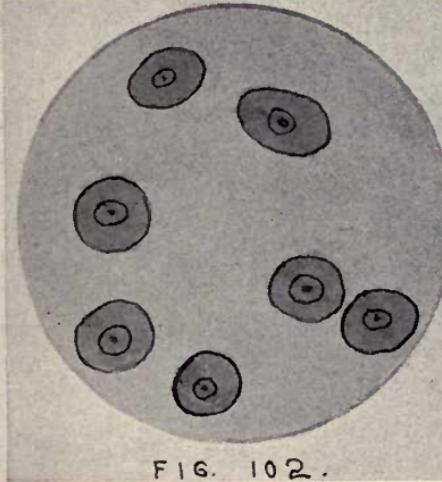


FIG. 102.

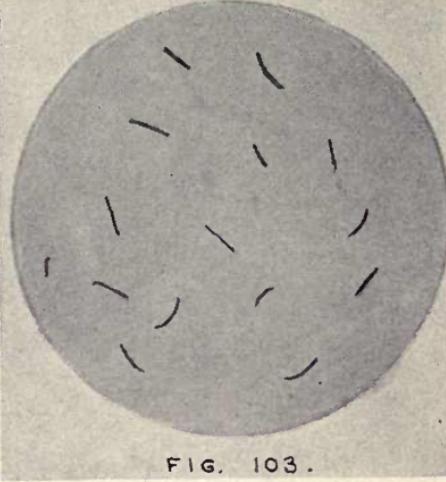


FIG. 103.

than the millimeter; or, the one-twenty-five thousandth part of an inch.

Now, the diameter of the microbe is three and one-third times the one twenty-five thousandth part of an inch; which is the one seven thousand five hundredth part of an inch.

Here, then, are two spheres; the drop of water, the one twenty-fifth part of an inch in diameter; the microbe, the one seven thousand five hundredth part of an inch in diameter. The problem is, to see how many times the latter is contained in the former.

Spheres are to one another as the cubes of their diameters. The cube of $\frac{1}{25}$ is $\frac{1}{15625}$. The cube of $\frac{1}{7500}$ is $\frac{1}{428875000000}$. The former cube divided by the latter is exactly 27,000,000. Therefore the microbe, which is the $\frac{1}{7500}$ part of an inch in diameter, is contained in the drop which is the $\frac{1}{25}$ part of an inch in diameter, 27,000,000 times. That is to say, the microbe of consumption is so small that 27,000,000 of this being may be placed in the space occupied by a small drop of water.

But, small as this germ is, it is yet, as before said, the most terrible enemy of mankind. Great Alexander conquers a world, and weeps for more worlds to conquer. This tiny being attacks the great general; he is slain. It attacks a thousand, a million Alexanders; they are slain. So on indefinitely.

How are such victories won? In one of many ways this tiny being gets into the lungs. Here it

finds its natural food. Here it slowly grows. Here it slowly multiplies. In the course of a long time, usually many years, the microbe multiplies into great numbers. By their life processes they generate the consumptive poison. This poison permeates the entire system. The onset of the disease now has full sway. All its symptoms come to the front,—tubercles in the lungs, the ragged cough, the night sweat, the hectic flush, the once robust form now a bending skeleton,—final relief in the eternal sleep. Or by a lucky hemorrhage the sleep comes earlier, suddenly. 5,357,142 such cases every year!

What can be done to sweep this scourge from the world?

First of all, understand what consumption is. Tell the truth to the people,—the whole truth, nothing but the truth. Tell it in newspapers, in magazines, in lecture rooms; from the pulpit. Tell it over and over again, until the people know it all. Darkness is death; light is life. Let the light shine.

Consumption is not hereditary. The parent never communicates the germ to the unborn child. Nature forbids that outrage. But the germ may be communicated to the child at any time after birth. True, the disease frequently runs through a family; but this is solely because the first member who has it communicates the germ to the other members. In every case the germ comes from a previous case.

Consumption is therefore contagious and infectious,— in the same sense that any other disease is contagious and infectious. Many are the ways in which the germs are transmitted from one person to another.

The kiss is exceedingly dangerous; it may prove a death shot to the well person.

Occupying the bed with the patient, is a danger almost too obvious to mention.

Germs are on the patient's hand. You take his hand in yours. Germs are transmitted to your hand. Your hand finds its way to your mouth. From your mouth the germs find their way to your lungs. Infection is sure.

The germs may live in furniture for years, and then be transmitted to the persons using it.

The germs may be carried on the hands, or in clothing, and be conveyed from person to person. Doctors, or others, may so carry them from house to house.

Pet dogs and cats may carry the germs in their fur, associate with other dogs and cats on the street, and these others carry the germs to their homes.

Flies light on the patient, or on his sputum. Millions of germs adhere to the feet and body of each fly. They go to other rooms. They light on other members of the family, or on the food they eat. They may find their way to other houses. Thus flies transmit the disease.

Milk from tuberculous cows, or water tainted with germs, may cause the disease.

Most of all, infection takes place by breathing the air in which the germs float. The sputum of the consumptive always contains millions upon millions of germs. In his room, on street or sidewalk, car or coach, the sputum dries and crumbles to dust. By stir of brush, broom or wind, particles of dust, with germs clinging to them, rise and float in the air. The air is breathed into the lungs; infection is the result.

In all these, and in many other ways, the contagion of tuberculosis is communicated from person to person. The germs are scattered broadcast over the world. Everybody is exposed to the disease. All consumptives mingle freely with all other people; the exposure is therefore inevitably universal.

Is it any wonder, therefore, that one seventh of all the people die with tuberculosis? Is not the wonder, rather, that more do not die with it? Indeed, that all do not have the disease?

Why not? One reason, and one only,—a wise provision of Nature forbids. By Nature, the larger portion of mankind, say six-sevenths, is not predisposed to consumption. All individuals of this portion are immune. They cannot have the disease. But the other portion, say one-seventh of mankind, is predisposed to, can take, does take, the disease, and dies with it in vast numbers.

Why this is so, why one portion of mankind is

predisposed to consumption, and the other portion is not, is perhaps not fully known. But the probable reason may be found in the law of the survival of the fittest. Of all the people, originally, the individuals best fitted by nature to fight and ward off disease, have, during the evolution of man for centuries, transmitted their qualities from generation to generation, until now their descendants constitute the portion safe against the disease; while the individuals, originally unfitted by nature to ward off the disease, have also transmitted their qualities through all the generations, and their descendants now constitute the portion predisposed to the disease.

But why, originally, a part were predisposed, and the other part not, is still the mystery.

Perhaps, however, the most wonderful thing about this matter is yet to be told: In the face of all the facts to the contrary, the impression has generally prevailed throughout the world, and, to a large extent, still prevails, that tuberculosis is not contagious and infectious! On this basis people generally act:

Consumptives live in their homes, mingle as freely with their families, friends and society, as though they had not the disease. After long lingering sickness, they finally die in their homes, and have public funerals, as though no possible harm could be the result.

From such homes children go to school, associate with the other children, as though they could not

carry germs in their clothing and communicate them to the other scholars.

Sometimes, in such homes teachers board, attending to their daily duties in the school room, with no apparent thought of scattering the seeds of death among the scholars.

Consumptives, far gone with the disease, are elected to offices of public trust, here associate with their fellows in office and with the workmen under their charge, seemingly with no sense of spreading infection from their persons, or by their sputum, only too often scattered helter skelter. Two such persons were recently elected to offices in this city. The one served three years, and died within four months after leaving office. The other served three and a half years, working, in his poor way, with his associate officers and with the workmen under his charge up to, and on, the very day when he died!

This state appoints men,—paying them for their services,—to give public lectures on tuberculosis. Their duty is to enlighten the people on this subject. Two years ago, one of these lecturers gave an address in this city. He told the audience that tuberculosis is not contagious, but that it is hereditary. Two bigger errors could not have been spoken. He further claimed that tuberculosis is curable, citing himself as an example. The disease, he said, was in his own family. He had himself inherited it from his parents. After fighting it for years, he had cured himself. Then he pro-

ceeded to explain how he had wrought the marvelous cure. But that very moment this man was himself in the last stages of consumption! Within four short months he slept in a consumptive's grave!

These facts are by no means peculiar to any one community. They doubtless are patent the world over. They are here cited to show how indifferent people generally are in regard to the dangers of the Great White Plague. They seem to think that it is in no wise contagious, but that it comes in some mysterious way without any special cause!

The National Association for the Prevention of Tuberculosis appoints the last Sunday in April, Tuberculosis Day; requesting every clergyman in the United States to devote the day to the consideration of this disease. The result shows that the average clergyman knows about as much about tuberculosis, and is about as much interested in it, as the average layman!

The Red Cross attains about the same result.

Why this general apathy? In the face of a thousand facts which ought to arouse every community in the world to immediate action, why this dreaming indifference? Manifestly because people generally, lay and professional alike, are not well informed as to the nature of tuberculosis; because they do not believe, or, at least, do not sharply realize, that the disease is contagious and infectious; because, more especially, the disease is so slow in its development.

One member of the family has the disease and dies. All the other members are of course exposed. One or more of them may be predisposed, the others not. No immediate harm to any of them. Years pass, and all is well. A dozen years, or more, glide away, and the family is still happy. No signs of infection yet. But, finally, the plague develops in another member, and in that home is another vacant chair. The first sorrow, though not forgotten, is yet assuaged, healed. In no wise, except by name, is the second sorrow supposed to be connected with the first. Least of all, does any one for a moment suppose that the second member took the plague from the first. Oh no, it has been too long! The plague comes, they know not how. Certainly it is not "catching." It comes because it does come. That's all!

A thousand times this incident is repeated all over the world. A thousand times, with the same conclusion. The slow development is a blindfold to the origin.

In Africa the disease known as the "sleeping sickness" yearly dooms thousands upon thousands to a premature grave. From it no one recovers. It is caused by a germ communicated by the bite of a fly. After the bite, it takes about four years for the disease to show itself. When the natives are told this, they cannot believe it. To them four years hide the cause in oblivion. But if the effects from the bite of the fly should come on as suddenly as do the effects from the bite of the rattlesnake,

the natives would not need be told that the fly is responsible.

So, if tuberculosis, in all countries, came on as soon after exposure as does the smallpox, no one would need be told it is "catching." All would know it only too well, and fear its coming as they would fear the coming of forty cyclones.

Under existing circumstances, therefore, how to stamp out the plague is the great problem. Its grip is tightly clinched on the world, and the world is poorly prepared to shake it off.

But the world's pioneers are beginning to wake up to this evil and demand that something be done. Already a beginning is made. The problem is attacked by attempting to cure certain cases. If properly treated in its very earliest stages, no doubt tuberculosis may sometimes be cured. Sanatoriums are now being built for this purpose, and quickly filled with the supposed curables. So far, so good. But the experiment has not yet been tried long enough to determine what per cent., if any, of the supposed cases may be completely and permanently cured.

Meanwhile, the world is waiting for the discovery of the true consumptive antitoxine. In many laboratories throughout the world scientists are searching for a poison,— or something to create a poison,— which, taken at the right time and in proper doses, by the consumptive, shall counteract and destroy the poison generated by the consumptive microbes, and thus enable the patient to re-

cover. If discovered, such a remedy would be universal. Except in cases advanced beyond hope, the cure would be complete.

But even by this means the plague could not be exterminated. So slow and stealthy in its development, the great majority of cases before known, must scatter the germs for a new crop. Thus it would be the perpetually raising a new crop, and perpetually curing the old.

Great and good as this result would be, the world would still demand a more exhaustive treatment—a treatment that shall pluck up the disease, root and branch, and sweep it from the earth.

Therefore the world is waiting for the discovery of a more perfect remedy—a remedy which shall cure the plague by preventing it. Prevention is infinitely the best remedy. On this line bacteriologists in many laboratories are searching for a true consumption vaccine—a vaccine which shall be to consumption what vaccination now is to smallpox. Three hundred years ago the face of the entire world was pitted. The smooth face was the exception. But since the discovery of the smallpox vaccine by Jenner, there has been a perfect revolution. The face of the whole world is now smooth. The pitted face is the exception. The discovery of a similar vaccine for consumption would be followed by a similar revolution along this line. When everybody should be vaccinated by such a vaccine, nobody would have consumption. That fell destroyer would be driven out of the world.

But the millennium has not yet come. It is only a hope of the future.

What is the next best prevention? A rigid quarantine, and a rigid quarantine only. Build sanatoriums for the curables. Build more and greater sanatoriums for the incurables. Within their doors require, by law, all consumptives to enter. Except doctor and nurse, all others forbidden. Over every door, "No Admittance." Draw the line as stringently as for smallpox—and keep it drawn. The permanently cured to return to society; the others to remain.

But is not this severe? Separating the sick and suffering ones from home and loving friends? Most assuredly. Terribly severe. Little less than a legal outrage.

But what of it? The surgeon's knife is always severe. The deeper the wound, the deeper the cut. But which the severer,—knife or death? Those stricken with the Plague going to hospitals, where every necessity and comfort are provided for their well being,—or the continued suffering and death of more than five and a half millions every year? Which the greater outrage,—wholesale prevention in the kindest way possible,—or wholesale slaughter in the cruellest way possible? Which is wiser? The better? The kinder? The more humane?

On this higher basis we honor our domestic herds. The State draws the line. No Jersey, Holstein or other breed can come across until the tuberculin test is applied and the animal found whole. The

herd within must submit to the same ordeal; only the sound can live.

The trotter — what high grade care! How regular the massage; clean the stable; choice the feeding; constant the daily exercise in sun and air.

When our monkeys are first taken from their wild homes and confined in our zoölogical gardens, they die of The Great White Plague in great numbers. Being our cousins, no wonder! But we deem them worthy. Each one is tested with tuberculin. Only the sound are kept. Our sources of infection are cut off. Cages are sterilized, cleaned and supplied with abundant fresh air, sunshine, improved feeding.

Mortality is thus wonderfully lessened; in some zoos rarely a case. Soon the Plague will go forever.

Could men the world over deem themselves as worthy as our horses, cattle, monkeys — what joy to the world! The millenium would not be far away.

To be universally effective, quarantine and sanatorium must be universal. All nations must join in one holy alliance to fight the common foe. Cost and labor must not be considered.

But great bodies move slow. Don't wait! The sanatorium is educational. It shows us how to care for ourselves. In curing the curables, its factors are rest from overwork, open air, sunshine, abundant feeding. But these, we now know, are the identical means needed to keep the Plague from our own doors. **USE THEM!**

PART IV

MICROBES AND OTHER DISEASES

CHAPTER LXI

THE MICROBE OF APPENDICITIS

THE appendix is one of the Rudimentary Organs. A large number of these organs are found both in Man and the lower animals. They are organs once well developed, now dwindled to mere nothings. Their dwindling may require untold generations.

The cause of dwindling is disuse. The organ not used becomes smaller and smaller, finally vanishes. Some birds migrate from the mainland to lone islands in the ocean. Here they are away from enemies and therefore do not need wings for rapid flight. Unused, their wings, through many generations, dwindle to mere fragments. The birds can no longer fly.

Some fishes in dark caves have no eyes. Before introduced to the caves, their eyes were well developed. Once in the darkness, they could not use their eyes. Their eyes dwindled, vanished.

In the evolution of the lower animals, as higher and higher species are evolved, they do not need certain organs needed and used by the lower

species. Unused from generation to generation, these organs gradually shrivel away to mere fragments, finally vanish.

In the onward evolution of Man from the higher animals, with his upright position and new environment, he does not need certain organs needed and largely used by his ancestors. Unused through long generations, these organs, by slow degrees, degenerate into mere rudiments, at last to disappear.

Among many others, the appendix is such an organ,—a mere fragment of what it once was in some of Man's remote ancestors.

When these ancestors walked on all fours, the appendix was a part of the cæcum, the closed end of that organ. It was large and much used. But when the ancestors, by evolution, assumed the upright position as man apes, and then Man, this part of the cæcum was needless and unused. Therefore by slow degrees it shriveled up to what it now is in man. It is situated low down on the right side of the abdomen, wormlike, the size of a small quill, with a caliber sufficient only to receive the common knitting needle. One end is closed, the other end is open, unites with the remaining part of the cæcum and, through that, with the large intestine.

In some persons the appendix, no doubt, has disappeared. In others, it is but an inch long by a quarter of an inch in diameter. In others it is two inches long. In other, three; in others, four.

In none is it more than a third of an inch in diameter; in all, it is absolutely useless. It must go. Welcome the day when it is gone.

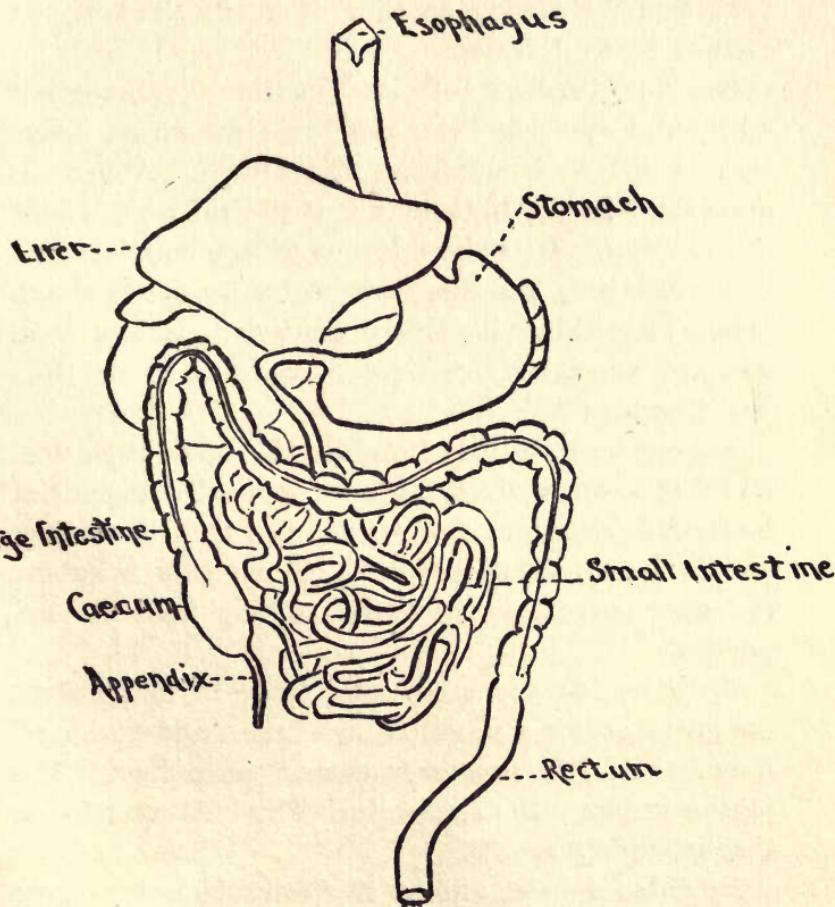


Fig. 98-a
Showing the Appendix

But it goes hard. Nature's method is slow. By almost imperceptible degrees, from generation to generation, must come the final good-by.

Meanwhile, the appendix is the occasion of not a little trouble. It is peculiarly liable to disease. This, for two reasons. First, because of its feeble condition. Growing smaller, it grows weaker. It cannot so well resist.

Second, because of its position. Connecting with, and opening into, the large intestine, infection is apt to come from this source. A certain microbe, Fig. 99, is the chief, if not the only, cause of infection. It is the microbe of appendicitis. It is Rod-shaped, has fine flagella on its body, which assist in making its lively motions. It has been isolated, artificially cultivated, and named *Bacillus Coli Communis*.

This germ naturally inhabits the small intestine. Here it always lives, and is generally harmless. From this organ it passes into the large intestine, and is here always present. From this intestine the germ occasionally finds its way into the appendix.

Then begins the mischief. Once in this organ, the germ grows and multiplies into great numbers. From their life processes comes the poison. The poison inflames the appendix. The inflammation is the appendicitis.

By this microbe, and by this microbe only, comes every case of this disease.

It is sometimes thought that a speck of solid substance from the intestine may enter the appendix and cause the disease. But it is not the speck itself — if it enters at all — which causes the dis-

ease, but the germs which the speck brings with it.

Another thing: During certain diseases, like the typhoid fever, scarlet fever, and so on, the bacillus coli communis is enormously multiplied in the small intestine. Hence, incident to such diseases, more of these germs than usual pass into the large intestine. By the greater number here, some are the more apt to enter the appendix. Hence the appendicitis is apt to follow such diseases.

But what shall be done? Call the up-to-date physician. External applications are first tried. If they do not relieve, and swelling appears, it means the formation of pus. The pus must be removed to prevent bloodpoisoning. Hence the surgical operation.

In case of this last resort, the greatest possible care must be taken to sterilize room, bedding, hands and clothing of doctor and nurse, and all material used. Sterilize, and keep sterilized, everything, until all danger is passed.

Last, but not least, use only the honest knife. Too often is the appendix cut out when nothing ails it. Two such cases, a girl of seventeen and a boy of ten, have just come within my personal knowledge. Thousands occur every year. The money fee, \$100 or more, is a strong temptation. Knowing the operation on the sound appendix is safe, doubles the temptation. Knowing that the State Medical Association furnishes money to any

member to defend a suit brought against him for mal-practice, trebles the temptation. Big fee, safety, free defense,—Why not slash? They do slash! Operations are surprisingly frequent. In more than two-thirds of the cases, no doubt, nothing ails the appendix. The knife is rampant after the fee!

Every layman should know how to diagnose the appendicitis. It is about as simple as it is to know when one has a cold. The organ being situated, as before stated, low down on the right side of the abdomen, near the surface skin, when inflamed, the inflammation soon shows at the surface. The skin is red, and sensitive,—sometimes attended with swelling, always with sharp pains. When these symptoms are all present, it is Appendicitis. When they are absent,—or absent except the pains,—the appendix is all right. The pain comes from something else—from pleurisy, colic, constipation, or some other difficulty.

So easily diagnosed, the surgeon has no excuse for doing a wrong job. Whenever he cuts out a normal appendix, he should prosecute his own knife. It knows better! Better curb ambition with a twisted bit. Reckless slashing slashes public confidence.

Especially be cautious with the aged. The caliber of the appendix in early life begins to contract and close up. At the age of thirty-five, in a quarter of the human race its cavity is completely closed against the cavity of the cæcum. At forty-five, its

cavity is closed in half of the race. At sixty-five, in few cases only is it not closed.

As all infection comes from the cæcum through the passage into the appendix, when this door is shut, this disease is, of course, impossible. Hence the fact that appendicitis is chiefly a malady of youthful days. Fifty per cent occurs between the ages of ten and twenty-five. As the years increase, the visitations decrease. At fifty, every person may reasonably congratulate himself as having passed the danger line. The knife then should think twice before acting once.

A leading physician in this city was taken ill. The surgeon diagnosed the case, pronounced it appendicitis, used the knife. He found it not appendicitis at all, but peritonitis, inflammation of the small bowel. Within forty-eight hours the distinguished patient was dead. No doubt appendicitis, in his case, had been impossible for ten, even twenty years.

May we not excuse gray hairs for not having impossible ills? Are not the possible enough? Is not discretion the better part of the knife?

CHAPTER LXII

THE MICROBE OF CANCER

THIS germ has been isolated,— taken alone from the cancer,— and cultivated artificially. By inoculating lower animals with the cultivated germ, the cancer has been produced in them. Evidently, therefore, this particular germ produces the cancer in the human subject.

Different varieties of the cancer may be owing to different varieties of the germ. In its every variety, the microbe propagates itself by the production of spores. In its mature form the germ is a minute cylinder.

In propagating, the internal contents of the cylinder are converted into minute round balls. These are spores. Each one is ready to grow into the mature microbe and propagate again.

The three stages of propagation are shown in Fig. 100. First, the little spheres. Second, the spheres grown into little oblong rods. Third, the rods grown into minute cylinders.

In every cancer this process of multiplication is going on continually. By its action the natural cells and tissues are broken down, destroyed; and in their place new and abnormal cells and tissue are formed, producing the growth of the tumor.

In their life processes, too, the germs generate the cancer poison. This poison enters the circulation, and, in the blood stream, goes to every part of the system. The germs go with it. They may be found in any drop of the patient's blood.

But the poison is not very virulent; it is slow in affecting the whole system. Though the cancer is not cured, the patient may live many years. The time will depend largely on the duration of the cancer. But, in any case, death comes at last.

The mortality from cancer in the United States is set at about 30,000 yearly. At this rate throughout the world, the yearly mortality is over a million.

When the right antitoxine is discovered, if applied early enough, no doubt, every cancer may be cured.

Meanwhile, if favorably located, the tumor may be removed. Consult a surgeon. Attend to it early.

But the best way is to prevent it. Remember cancer is contagious. It may be communicated from person to person.

Therefore exercise common sense. Sterilize. Disinfect. Keep clean. One word of warning should be sufficient.

Just now comes the news that Liquid Oxygen kills the cancer germ and cures the tumor. Known cases of cure are at hand. Worth trying. The boon may be here. If not, it soon will be.

CHAPTER LXIII

THE MICROBE OF ERYSIPelas

THIS microbe is shown in Fig. 101. It belongs in the Spherical Type. The germs are minute balls,— about the one-twenty-five thousandth part of an inch in diameter. They grow in chains or singly.

Infection usually, if not always, takes place by means of a wound— slight abrasion of the skin or more serious wound. The germ lives free in the soil—a soil microbe. Finding its way to some break in the skin, the germ here grows, multiplies in great numbers, and generates the poison peculiar to this disease. Entering the general circulation, the poison causes fever, headache, nausea, vomiting.

Inflammatory eruptions appear on the skin— usually on the face. At first, a slight red pimple. The pimple grows larger. The inflammation spreads. Or, several pimples may appear, grow larger, run together, and the inflammation spread wider.

The disease is very troublesome. It lasts about a week. The inflammation then subsides. The skin peels. The patient recovers.

But little can be done by way of treatment ex-

cept quiet rest and kind nursing. If the bowels do not move, use the enema.

To prevent erysipelas, sterilize the wound. A little water, with a drop or two of carbon dioxide acid, or a trifle of bichloride of mercury, applied to the wound, kills the germ, prevents all danger.

CHAPTER LXIV

THE MICROBE OF MALIGNANT CEDEMA

THIS is a rare disease. But, in considering anything like a complete list of diseases caused by microbes, it must be mentioned. It is popularly called "poisonous dropsy." The microbe that causes it is represented in Fig. 101-b. It belongs to the Rod-shaped type. It is about the one-twenty-five thousandth part of an inch in its shorter diameter — three or four times this in its longer diameter.

This germ propagates by the production of spores. The spores are formed in about the center of the rod. The minute rods begin to enlarge at the central point, and, when the spores, forming within, become mature, the membrane breaks, and the spores go free.

This microbe lives free in Nature — in garden and field soil and different kinds of manure.

Infection takes place by means of some wound on the body — slight scratch of the skin, or more serious wound. The sharp instrument by which the wound is made may contain the germ, and produce infection by leaving the germ in the wound. Or, after the wound is made, contaminated soil may come in contact with it, and thus produce infection.

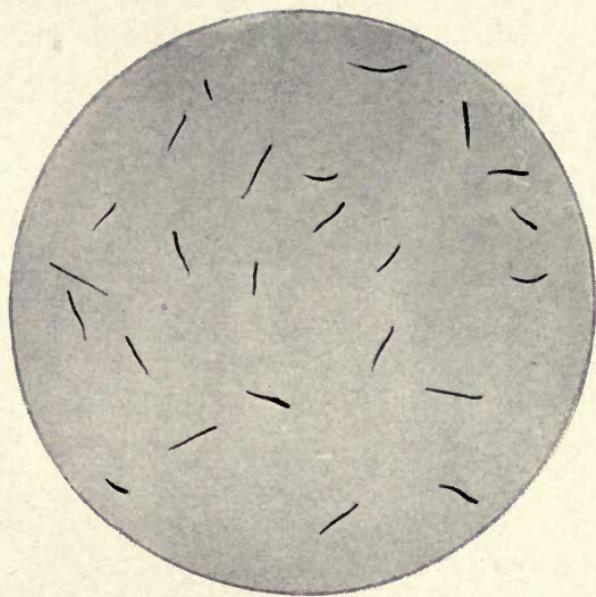


FIG. 101-B
MICROBE OF MALIGNANT OEDEMA



When once in the wound, the germ multiplies and generates a powerful poison. The poison does the mischief. It enters the circulation. It spreads through the system. Produces swelling — poisonous dropsy. Almost always fatal.

An antitoxine has been discovered for this disease. Call at once the up-to-date physician. He should bring the remedy. If applied early enough, the patient recovers.

The only way to prevent this disease is to sterilize the wound. A little solution of carbonic acid and water applied early to the wound destroys the germ, and bars all danger.

CHAPTER LXV

MICROBE OF THE CARBUNCLE

ANOTHER germ that lives free in Nature,—a soil microbe. Infection occurs in the usual way,—by some wound on the surface of the body. In adults, the wound is usually some slight abrasion of the skin on the hands; in children and youth, a wound on the hands, or,—if they go barefoot,—on the feet.

Once in the circulation, the germ may be carried by the blood stream to some other point on the surface of the body,—usually to the back of the neck, or between the shoulder blades. Or, if some little abrasion is made at this point,—possibly by the finger nails,—the germ may here enter directly from the contaminated nails; or from any other contaminated instrument.

Once in the wound, the germ multiplies, generates poison. The poison produces inflammation, breaks down the cells and tissues, finally converting them into pus.

Beginning as a mere red pimple, the carbuncle may become as large as a walnut or orange. At the proper time, if it does not break, it must be lanced; else the pus may be absorbed into the system and produce blood poisoning.

But beware! Every particle of the pus is alive with germs. If it enters other slight wounds, other carbuncles are the result.

A certain patient had a carbuncle on the back of the neck. It pained and itched. He scratched the skin around it. It broke. The pus entered the scratches. A crop of thirty-two other carbuncles was the result. The physician barely saved him from death by blood poisoning.

As soon as pus forms and issues from the carbuncle, freely apply the anæsthetic. Carbonic acid, or bichloride of mercury, properly diluted with water, is the stuff. It kills the germs, stops further harm.

But had the anæsthetic been applied to the fresh wound, no carbuncle would have troubled. How much better! Keep the anæsthetic on hand. Apply it to every little, or more serious, wound. You are safe.

CHAPTER LXVI

THE MICROBE OF PERITONITIS

THE peritoneum is a membrane that surrounds and encloses the intestines and other organs within the abdomen. The inflammation of this organ is the peritonitis. It is caused by a microbe.

This germ is a soil microbe. Many are the doorways through which it may enter the system and find its way to the peritoneum. Here it grows, multiplies, and very soon, by its great numbers, generates the poison peculiar to this disease.

This poison causes the inflammation, and the sharp, even agonizing pains. The inflammation and pain usually begin at a single point. Unless arrested, the disease then spreads more or less over the abdomen. This is the dangerous stage. A kind of mucous may be generated in such quantities as to glue the intestines more or less together, causing obstinate constipation.

An operation is then the only hope. The intestines must be separated, cleansed, and restored to normal condition.

At the very onset of this disease, call the most skillful surgeon at hand.

CHAPTER LXVII

MICROBES IN SURGERY

TRUE, many an accidental wound on the surface of the body,—however slight, however serious,—is the doorway for the entrance of many an invisible foe.

True, many a disease is the result. Many an infection,—many an inflammation, local or widespread,—many a pus formation, many a blood poisoning.

True, the discovery of this evil and how to prevent it, has conferred upon the world a great benefaction; sterilize the accidental wound as soon as possible after it is made. Sterilize the wound,—however slight or serious,—and keep it sterilized until all danger is past. The wound is thus healed from first intention. The invisible foe is killed before it enters the circulation.

But this is only one-half the story. The invisible foe, the same in kind, the same in number, enters the wound purposely made by the surgeon, as readily as it does the wound accidentally made. The resulting evil, too, is equally great.

Hence the knowledge how to prevent this evil has conferred upon the world another, and, if possible, greater benefaction.

Kill the bad germs before they enter the surgeon's wound. The wound will then heal from first intention. There will be no inflammation, no pus formation, no blood poisoning, no "complications of other diseases."

Sterilize operating table, surgeon's hands, instruments. Sterilize nurse, hands, all material used. Sterilize everything, and keep it sterilized till danger is passed. Kill the microbes which trouble in surgery before they trouble.

In his practice, the up-to-date surgeon requires all this; all other practice is mal-practice.

CHAPTER LXVIII

THE MICROBE OF DYSENTERY

THIS microbe is shown in Fig. 102. It belongs in the animal kingdom, and is an amœba. As a disease germ, it is exceptionally large,— about one thousand five hundred times as large as the average disease producing germ. It is yet invisible to the naked eye.

As seen in the figure, this microbe consists of a sac filled with protoplasm. At the center is a nucleus. Within the nucleus, a nucleolus.

The germ multiplies by Fission,— first prolongs, then divides into two parts. Each part prolongs, and divides as before. And so on.

It is a tropical animal — hence the disease is endemic in the South, appearing in the North during the heated season of Summer.

Infection takes place by way of the rectum. Once there, the germ finds its way into the large intestine. Here is always located the disease. Once here, the germ grows, multiplies, generates the dysenteric poison.

The poison brings the onset of the disease,— inflammation of the membrane, sometimes ulcerations, frequent bloody stools, griping pains.

Little else can be done save the best nursing.

Keep the patient in bed and warm. Give only liquid or easily digested food. An enema of warm water every day.

Avoid all drastic drugs; they only injure.

Homeopathic treatment is sometimes effective. Dissolve twenty-four pellets of mercurius in a tumbler of water. Take one teaspoonful every fifteen minutes.

This has been known to cure. The disease always affects the liver. Mercurius in this form acts on the liver and brings relief.

Sooner or later, we may hope, the true anti-toxine for this disease will be discovered.

CHAPTER LXIX

THE MICROBE OF CHOLERA INFANTUM

THIS disease is responsible for about 30,000 deaths every year in the United States,— 500,000 in the world. All, or nearly all, are children under two years. It is another “slaughter of the innocents.”

No disease is more easily preventable. These infants and children subsist largely on milk. The milk, before it is taken from the cow's udder, contains no microbes. But as soon as milk comes in contact with the air, germs come into it from the air. In six hours, if kept open to the air, each quart,—especially in hot weather,—may contain 100,000,000 germs. To adults in vigorous health, no harm. To the innocents, cholera infantum.

At least, certain species of these germs are always the cause of this disease. How easy, then, to prevent. Sterilize the milk. Keep it sterile until it gets to the stomach. Heat to 170 degrees,—no more, no less. This kills the germs. Heated to the boiling point, 212 degrees, it may constipate. Heated to only 170 degrees, it is all right. The bad germs are killed. The milk is safe.

But be particular. It is all important. Each morning put as much rich Jersey milk into pint

bottles as is required for the day. Set the bottles in a kettle of cold water on the stove. In thus heating, the bottles will not break. Place in the water a thermometer. Heat until the thermometer registers 170 degrees. Then remove the bottles. Cork each with sterilized cotton. This keeps out all other germs. Feed as required. Feed clear. Dilute not with a drop of water.

After using the milk, cleanse the bottles in boiling water each day. If the nipple is used, boil it twice a day.

If the mother nurses her child, she should herself take only milk that is sterilized.

Two things more: First, use not a particle of prepared "baby's food." It is prepared to keep — embalmed! A baby killer!

Second, not a drop of "soothing syrup." Every drop contains laudanum or its equivalent. A poison! True, it soothes to sleep. Yes, to the eternal sleep!

Follow these directions,—fear not cholera infantum.

CHAPTER LXX

THE MICROBE OF CHICKEN POX

THOUGH adults occasionally have this disease, it is properly a child's disease. It is strictly caused by a microbe, and it is contagious. The germ may be carried on the hands, in clothing, and be communicated from person to person.

The onset comes in about twelve days after infection. There is fever, headache, sometimes vomiting. Red spots appear on the skin, attended with itching.

The disease is mild, and soon over. Only careful nursing is required.

But prevention is the word. Do not allow the disease to become epidemic. There is not the slightest need of it. Quarantine the first case; and every case. Thoroughly disinfect. Kill all the germs, and the disease is killed.

CHAPTER LXXI

THE MICROBE OF GERMAN MEASLES

BOTH children and adults have this disease; more of the former than of the latter. It is exceedingly contagious and infectious. The germs are carried in clothing, and in many ways communicated from patient to others. Doctors frequently carry the disease from house to house.

The germs, too, float in the air. A single scholar, with the measles in a schoolroom, may give the disease to every other scholar in the room, including the teacher. Such instances are on record.

In ten days,—sometimes a little later,—after exposure, the disease makes its appearance. It begins like a common cold,—coughing, sneezing, excretions from nose and throat, fever and headache. Red eruptions appear, first on the face, then on the body.

The symptoms gradually disappear in about ten days. In ten days more recovery may be complete.

By way of treatment, keep the patient in bed and warm all the time. Administer warm drinks — a light and easily digested diet.

Aside from careful nursing, little else can be done.

Although the disease is usually mild, its annual death roll in the United States is about 15,000. In the world, 250,000. Yet easily preventable!

A shame and disgrace to twentieth-century civilization! Boards of Health are usually responsible for every epidemic.

Gentlemen, open your eyes to duty. Draw the cord of quarantine taut, and keep it taut. Police the door to the first subject—to the second, to every patient. No entrance except doctor and nurse. Doctor to disinfect self before he steps a foot into another house.

Fifteen thousand graves call on you, gentlemen, to look that death roll squarely in the face, and reduce it to nil.

CHAPTER LXXII

THE MICROBE OF GLANDERS

THIS disease is natural only to horses and other equines,—asses and mules. From these equines the disease is, under certain conditions, communicated to man.

The cause of glanders is always the microbe represented in Fig. 103. It is Rod-shaped. The rods are straight, or slightly curved, and very minute.

The germ lives free in nature. By some wound, usually on nose or feet,—however slight, the horse, or other equine, first becomes inoculated with the germ, has the disease. Then from the equine the disease is communicated to groomsmen, or others, who work with, or care for, the equine.

To these workmen the disease is practically confined. Usually by some slight abrasure on the hand, the germ enters the circulation. Here the germ multiplies and produces the glanders poison.

First, at the point of infection there is inflammation, swelling and the formation of pus. The poison and germs are then carried to other parts of the system. Inflammation, swelling and the formation of pus in these parts. Almost always the disease is fatal.

The groomsman may reasonably hope for the discovery of the antitoxine that shall cure. Meanwhile, look out. Be cautious. The moment an animal is found to have the disease, cease to groom or care for it. It should at once be killed and cremated. Then disinfect self, harness, stall,—every-thing tainted.

Generally to wash hands once or twice a day in carbonic acid diluted properly with water, would be the part of wisdom.

CHAPTER LXXIII

THE MICROBE OF DECAYING TEETH

EVERY permanent tooth in the human jaw is surrounded by an enamel covering. Nature forms this covering to protect the inward parts of the tooth,—the dentine and pulp. It is beautifully adapted to this service,—as hard and white as ivory.

Microbes cannot penetrate this protective shield. So long as it remains whole and perfect, the tooth is healthful and sound. But the moment any little fracture of the enamel occurs, it is an open door for the entrance of bad germs to the inner parts of the tooth. These germs come into the mouth from the atmosphere, are always ready to enter any and every breakage of the tooth's covering. Once in the wound, they here grow, multiply, and by their life processes generate the putrefactive poison which causes the decay and death of the tooth.

All the woes of teethache, ulcerations, and loss of teeth, are owing to the work of these germs.

And yet all this is preventable! Preserve the covering of the teeth. Keep out the foes. That's all.

Possibly this cannot always be done perfectly; but, with patience and scrupulous care, it can be

done so well as to preserve the teeth for many, many years — even to old age.

First. Keep the teeth clean. Brush them immediately after every meal. Brush lightly, so as not to wear the enamel.

Second. Don't bite hard substances. Don't use the teeth for a chisel or cleaver!

Third. The moment a fracture or cavity is discovered, go to a dentist and have it remedied.

Fourth. Go to an up-to-date dentist once a year, and have the teeth examined and cared for.

CHAPTER LXXIV

MICROBE OF THE SLEEPING SICKNESS

THIS disease is endemic in Africa, and is practically confined to that country. It is caused by a microbe which, no doubt, is also confined to that country.

Infection takes place by inoculation. The germ enters the circulation by the bite of a certain fly. The fly with its proboscis, in biting, deposits the germ.

Once in the circulation, the germ slowly multiplies, slowly generates the sleep-producing poison.

The period of incubation is about four years; or, at least, it takes about this time from the bite of the fly to bring the onset of the disease. The patient then begins to sleep, is inclined to sleep on and on, until he sleeps the eternal sleep.

From this disease no one ever recovers. Thousands upon thousands die of it annually.

For the disease no antitoxine is yet known.

The one thing to do, therefore, is to prevent the disease. First, the native should protect his person against the bite of the fly. Second, the government should make war upon the fly, and exterminate it.

CHAPTER LXXV

THE MICROBE OF HYDROPHOBIA

A DISEASE of the nervous system, central in the brain. It is caused by a microbe. Infection takes place by the bite of a mad wolf, mad dog, or other mad animal. Saliva in the mouth of the animal contains the germs. By the bite the germs, with saliva, are introduced to the wound.

Thus getting into the circulation, the germs multiply and generate the poison hydrophobic. By the bite of a certain mosquito comes the malarial fever; also the yellow fever. Precisely in the same way, by the bite of the mad dog comes the hydrophobia.

The period of incubation, or the time from the bite to the onset of the disease, varies considerably in different cases. But the average time is about forty days.

Among wolves in Russia,—where they abound,—hydrophobia not unfrequently becomes epidemic. They bite, and destroy the lives of many domestic animals,—horses, cattle, sheep,—and many human beings.

The bite of the mad wolf is five times as bad as the bite of the mad dog. Out of every hundred bitten by the former, eighty-six die. Out of every hundred bitten by the latter, sixteen die.

But the bite of the mad dog is bad enough. As the disease develops, it sets on fire the brain, and throws into convulsions the whole nervous system. It needs no description.

What do? The moment one is bitten, call the up-to-date surgeon. He will cauterize the wound. This will prolong the period of incubation, and thus give more time for treatment. He will then take the patient to the nearest Pasteur Institute.

The patient here will receive the Pasteur treatment. If he arrives in season, the treatment will surely cure.

The surgeon in charge has on hand mad dog virus attenuated a la mode Pasteur,—weakened successively, degree by degree, by passing it through a series of monkeys, till the weakest degree will not kill.

As soon as the patient arrives at the Institute, the surgeon inoculates him with virus at weakest degree. The body cells of the patient set up in his system antitoxine which counteracts the virus.

On the second day, the surgeon inoculates the patient with the next stronger degree of virus. The body cells of the patient continue to set up antitoxine which counteracts this virus.

The third day, the surgeon vaccinates his patient with the next stronger degree of virus. By continuing their work of setting up antitoxine, the body cells prepare the patient to resist this third degree.

This process is continued until the patient is

vaccinated with the full strength virus; when the patient, by the continued work of his body cells, is fully prepared to meet this.

About this time is ended the period of incubation. The disease should appear in full force, with full strength virus, from the bite of the dog. But the patient is already prepared to meet it. He is cured.

But prevention is better than cure. First, put a bounty on the wolf, high enough to exterminate that animal. Second, put a license on the dog high enough to make the number of canines beautifully less. The value of human life is above that of the wolf or dog!

Third, when the cry of "mad dog" is heard, do not rush into the street and be bitten; stay indoors, and be safe.

CHAPTER LXXVI

THE MICROBE OF INFANTILE PARALYSIS

INFANTILE paralysis is properly a disease of childhood. As a general thing, only children have it. Adults may have it, but only rarely. Some domestic animals, including birds, may also have it.

This disease is a disorder strictly of the nervous system, located centrally in the marrow of the spinal column.

Being contagious and infectious, infantile paralysis is caused by a microbe. The germ, like the germ of lockjaw and some other diseases, is, no doubt, a microbe of the soil. It lives free in garden soil, field soil, road soil.

This probably explains why infant paralysis is known as a child's disease. It may be simply because children play more in the soil, and therefore are more liable to become infected by the germ.

In this light, another mystery is cleared up: A single case of this disease sometimes breaks out in a lone neighborhood, where no other case for a long distance around has occurred for many years. Where does it come from? This is the mystery.

But, considering that the germ which causes this disease is a microbe of the soil, and present everywhere in the soil, the mystery vanishes. The ex-

planation is plain. The child is playing, perchance in the soil, at the very door of its own home. The germ is in the soil. By it the child is infected and has the disease. In the same soil the child may have played a hundred times before and escaped. This time it happens to be caught.

Infantile paralysis has two modes of infection.

One by means of some slight wound or scratch. The wound may be on the hand, forearm, or, if the child goes barefoot, on the foot. Having such a wound, the child plays in the soil. The germ, being in the soil, comes in contact with the wound. It hence enters the circulation, and, through some nerve, finds its way to some ganglionic center in the marrow of the spinal column. Once here, the disease is sure.

The other mode of infection is by way of the nostrils. The germ is undoubtedly among the very smallest. Under rare circumstances, it rises on particles of dust and floats in the air. Breathed into the nostrils, it finds its way directly to the spinal cord where it joins the base of the brain. Once here, again the disease is sure.

Infection may possibly be caused, also, by the bite of some insect which has previously bitten a person or animal having the disease. In such case the insect inflicts the wound and inserts the germ at the same instant.

By any mode of infection the germ finds its natural nexus, the spinal cord. Here it rapidly multiplies into millions. By their life processes

the germs generate the terrible poison peculiar to this disease. Permeating the nervous system, the poison produces paralysis.

Probably the paralysis takes place, for the most part, below the point where the germ enters the spinal cord. Hence, when infection comes by way of some little wound on the lower parts of the body, as foot or leg, the germ finds its way to a ganglionic center low down in the spinal cord, and therefore only the feet and legs may be paralyzed.

In this case, if the paralysis is slight, the patient may completely recover, the parts becoming normal. But, if the shock is severe, the feet and legs will be crippled through life.

Since the germ of this disease is everywhere present in the soil, it might seem that the disease should be more common. But the germs which cause lockjaw, malignant œdema, carbuncle, and puerperal fever, are likewise everywhere present in the soil; and yet those diseases but rarely occur.

The explanation is that many of the workers in the soil and of others similarly exposed, become immune. They cannot have the disease anyway. Moreover, for good reasons, the chances are always against infection. The wound through which the germ might enter would rarely occur. Rarely, too, would the person breathe into the nostrils the germ. Therefore, in the nature of things, just as it happens, the disease itself would but rarely occur.

In the near future, it is hoped, the microbe of

infantile paralysis will be isolated. Then a pure culture will be formed. Experiments with the culture will be made on lower animals. The results will be the discovery of the true antitoxine for this disease. By its timely use the disease may be checked, cured.

Meanwhile, perfect quietude for the patient, careful nursing, with gentle stimulants, are about all that can be done.

CHAPTER LXXVII

THE MICROBE OF PELLAGRA

PELLAGRA is a disease which, until recently, has been veiled in mystery. The word comes from two other words — one a Latin word, *pellis*, signifying skin; the other a Greek word, *agra*, which means disturbing.

Hence, while the cause of the disease was unknown, yet, because by it the skin was so much disturbed, it was named *pellagra* — a skin-disturber.

Thousands upon thousands have suffered with this disease, in their homes or in hospitals, both in Europe and in America, and have everywhere been treated by physicians who knew not what the disease was. Some physicians have treated the malady as a skin disease; others, as a nervous disease; others as scurvy; still others as the so-called Italian leprosy.

But the medical profession, as a whole, seemed to have on its hands an elephant, and therefore called the disease *elephantiasis*!

All the patients have thus been made the victims of guesswork and experiments. The drugs administered have done only harm.

When the physician does not know what the disease of his patient is, and yet claims that he does,

and deals out drugs to him to see what effect they will have — this is mal-practice pure and simple. An honest physician would frankly confess that he does not know, and decline to give medicine. Any other course is professional dishonesty.

Pellagra is bad enough without being made worse by drugs. Among other things, the patient suffers complete physical prostration, and the deepest melancholy, with his body gradually growing dark and darker, until, in many cases, it becomes coal black.

But, happily, by recent investigations the cause of pellagra is well understood. The disease comes from the use of spoiled or mouldy corn for purposes of food or drink. In spoiling or molding, a microbe, the fungus of mold, generates in the corn poison. This poison finds its way to the stomach in the food or drink, and thus causes the disease.

The microbe that causes this disease is different from all the other disease-producing microbes considered in this work. It is much larger, and works its mischief in a different way. All the others, as already seen, first enter the body, then by their life processes generate the poison. But this one does not enter the body at all. It lives outside the body, free in nature. When corn is not thoroughly ripened, or fails to be well cured, this microbe attacks the kernel, generating the poisonous mold.

When corn, thus poisoned, is used for food, the

microbe by cooking is killed, but the poison is not killed. It remains in the food.

When, too, such corn is used for making beer, in malting and brewing, the heat kills the microbe but does not destroy the poison. That remains in the beer.

Such poisoned food or beer, taken into the stomach, is the sole cause of pellagra.

What shall be done? Possibly in the near future chemists may discover a chemical antitoxine which shall exactly counteract the pellagra poison. If so, by administering it to the patient timely and properly, the disease may be cured.

But the best thing is to prevent the disease. No disease is more easily preventable. Stop using spoiled corn for purposes of food or drink, and pellagra is at once and absolutely prevented.

The corn crop this year in the United States is over three billion and forty-six million bushels. A mere moiety of it is poisoned in curing. For the owner to sell this poison for the purposes of food and drink, is a crime. For the buyer to sell it again for such purposes is another crime. Let government pay a high bounty for the detection of both criminals, and when convicted, severely punish them.

By this means, it is believed, pellagra would be soon stamped out,—thousands of lives saved every year.

BOOK FOURTH
PROTECTION AGAINST OUR INVISIBLE
FOES

PART I

NATURE'S DEFENSE

CHAPTER LXXVIII

THE GREAT FACT

FORTY-FOUR contagious and infectious diseases attack Man. Forty-four species of Invisible Foes are the active causes.

In the fight, 30,000,000 human beings fall every year. All the wars between man and man of a hundred years do not begin to make such slaughter.

Each foe is identified by its peculiar traits; yet all the forty-four different kinds have traits in common.

They all are so small as to require a powerful lens to reveal them to the naked eye.

They all are transparent; only by the use of staining dyes can they be seen at all — even with the powerful lens.

They all take food in the same way — by absorption through surface of body.

They all digest their food before absorbing it.
They all are mobile — can move.

They all propagate.

They all multiply — some wonderfully fast, one becoming 16,500,000 in 24 hours.

They all, except one, enter the body before producing disease,—by the air passages, digestive tract, or wound.

Once in the body, they all subsist on substances in the blood or in the tissues.

In their life processes they all generate poison,—forty-four kinds of poison—forty-four kinds of sickness and death.

By the same means, too, each germ is known to be the sole cause of a particular disease.

First, the germ is always present in the disease.

Second, the germ is isolated.

Third, of the germ a pure culture is made.

Fourth, a speck of this culture is used to inoculate some lower animal.

Fifth, the animal has the disease.

By these means the forty-four kinds of microbes are known to be the causes of the forty-four kinds of diseases.

Of the 1,500,000,000 people on the earth, each one is in danger,—however slight, it is yet danger. He knows not how soon he may be attacked by some one of the foes,—the next year, or the next moment.

“To be forewarned is to be forearmed.”

Such, Summed Up, Is the Great Fact.

FIG. 104

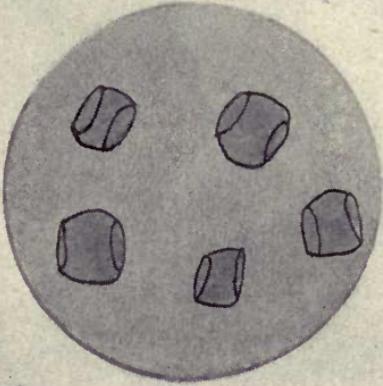


FIG. 105

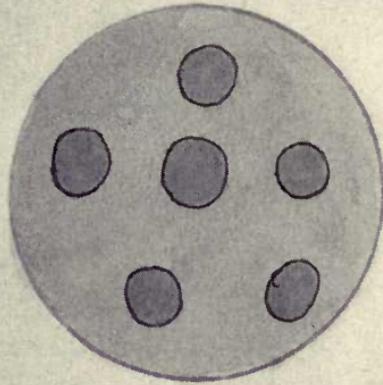


FIG. 106

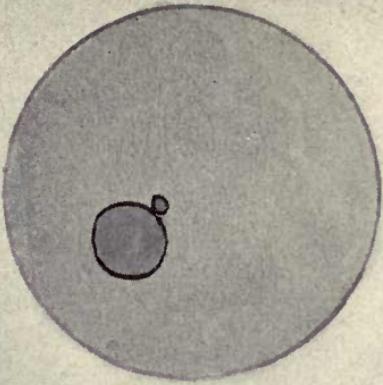


FIG. 107.

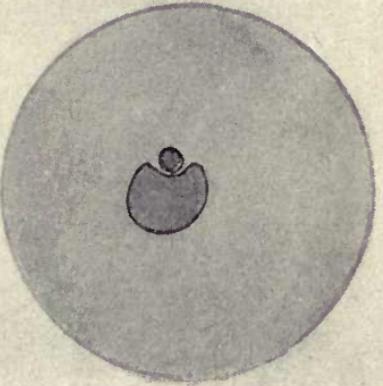


FIG. 108

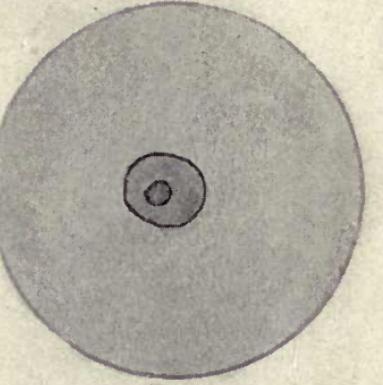
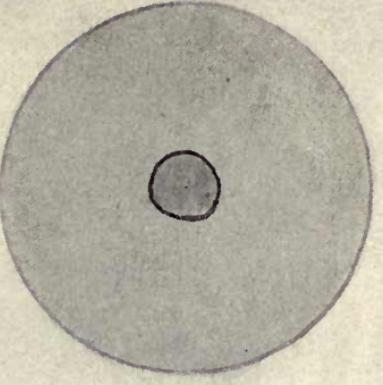


FIG. 109



CHAPTER LXXIX

DEFENSE BY WHITE CORPUSCLES

ONE-EIGHTH the weight of a man is blood. Taking the average weight of adult men to be 160 pounds, the average man has 20 pounds of blood.

In every cubic millimeter,—or drop,—of this blood are four million red corpuscles, and ten thousand white corpuscles. At this rate, the blood of the average weight man contains 32,500,000,000,000 red corpuscles, and 81,250,000,000 white corpuscles.

The Reds are spheres flattened at the poles so as to be biconcave discs. Their longer diameter is about $\frac{1}{2500}$ part of an inch; their shorter $\frac{1}{7000}$ part. Fig. 104.

The Whites are about three times as large as the Reds, and each one is, comparatively, a perfect sphere. Fig. 105.

The Reds do great work for the body. They constitute one-half the blood. They give to the blood its red color. They circulate with the blood. As the digested food is poured into the blood stream, they each seize a particle, carrying it to all needed points in the body. Circulating in the blood through the lungs, as each breath draws into those organs a fresh supply of oxygen, the Reds seize

each its little quota, distributing the life-giving influence to all points in the body. On the return of the blood stream to the lungs, each of the Reds brings back a particle of waste material, rendering the blood stream purple,— to be expelled in exhalations.

Thus the Reds serve to nourish, vitalize and keep clean the entire body.

On the other hand, the Whites serve to protect the body. Their office is to defend the Reds against foreign enemies and thus to defend the body against disease. Several times larger than the Reds, the Whites make good defenders.

Compared with the disease germs, the white corpuscles are giants,— 640 times larger than the microbes of tuberculosis, about 600 times larger than the average disease germ. Hence they are finely prepared to help defend the body against the invisible foes.

This defense is natural,— simply in accordance with the Order of Nature by which one form of life subsists at the expense of some other form. The stronger insect devours the weaker; the big fish eats up the little fish; the bird of prey scoops up the dove; man subsists on many lower animals, and, as a cannibal, eats his fellow man.

So the big microbe eats up the little microbe. Were it not so, it would be a break in the Order of Nature.

But such is the fact. For this reason the white corpuscles are called phagocytes,— the word means

cell-eaters. They are also called leucocytes,—a word meaning white cells. They are white cells themselves; and they devour disease germs, which are much smaller cells.

The Whites feast on the disease germs as a choice morsel. Fig. 106 shows a white corpuscle having just come in contact with a disease germ.

Fig. 107 shows a cavity forming in the corpuscle, with the germ being drawn into it.

In Fig. 108 the germ is enclosed. In Fig. 109 the germ is digested, absorbed, assimilated, and the phagocyte is ready for another feast.

A wound occurs somewhere on the body. Bad germs come into it from the air. They begin to grow, multiply and produce poison. But at this moment white corpuscles flock to the wound and devour the invaders in great numbers. If their work is sufficient, the wound heals without blood-poisoning. If not, in the absence of other antisepsics, the poisoning may be serious.

One is taken by some contagious and infectious disease. The germs enter the circulation, and multiply at a great rate. But here they are met by the white corpuscles and devoured in great numbers. If the protection is sufficient, the patient has the disease but lightly, and soon recovers. If not, the patient has a severer run of the disease, and may die.

This part of Nature's defense, in so far as it goes, is of course ontogenetic, that is, defense in the individual. And the nation, being composed of in-

dividuals, should, and does, have a corresponding phylogenetic defense, or defense in the nation.

Accordingly, the individuals of every well developed nation consist of two classes,—civilians and soldiers. The civilians do all the arts of industry; the soldiers form a standing army for protection.

The correspondence is perfect. In the body the red corpuscles are the civilians; the white corpuscles the soldiers. The individual is to the nation what the corpuscle is to the body. So perfect is this relation that the ratio between the protecting and the working forces in the body and in the nation is practically the same.

As already stated, the number of white corpuscles in the blood of the average adult is 81,250,000,000; and the red corpuscles, 32,500,000,000,000. This is exactly as one to four hundred,—one soldier microbe to four hundred civilians.

Now take the seven best developed nations,—England, Germany, France, Italy, Russia, Japan, the United States. As near as can here be calculated, the average number of soldiers, during the last decade or so, in the standing armies of the seven nations, is 2,374,000. Their civilian population, 950,947,000. Practically, one soldier to four hundred civilians. In each case the ratio is the same. In each case it is Nature's defense.

When the evolution of Man shall attain a certain degree of perfection, he will, no doubt, be able to conquer all disease germs, and keep them out of

the body. The Whites will then no longer be needed for protection; they will, in this respect, become rudimentary organs, and, if they have no office, finally disappear.

When the evolution of the nations, too, becomes more or less perfect, they will, no doubt, settle all disputes by peace arbitrations. Their soldiery will no longer be needed. Their standing armies will become rudimentary organs and pass away.

CHAPTER LXXX

DEFENSE BY THE BODY CELLS

THE gray cortex of the brain is composed of many millions of cells. They do the thinking. The other portions of the brain contain millions more cells. All, together, do the whole work of the brain.

All the other organs of the body,— heart, lungs, liver, kidneys, and the rest,— contain each a corresponding number of cells. All the cells of each organ, as so many individuals, act together as a single community, to do the work required for the well-being of that organ. All the single communities also combine together in one grand union to do the general work required for the well-being of the whole body.

Especially, in times of danger, each organ contributes its own share of help,— all uniting in one community to protect the body; just as, when the nation is threatened by foreign foes, each state in the Union contributes its own quota of soldiers to make up the grand army of protection.

The body is attacked by a contagious and infectious disease. Having gained entrance, the germs grow, multiply, generate the poison which does the mischief. The poison taints the circulation. The danger is sensed by the whole system.

At this moment, the phagocytes make a direct attack upon the invaders themselves. Feast on them, devour them, in full satisfaction of appetite.

At the same time, the alarm is sounded through all the communities of the body cells. Each community is aroused to do its share of defense. As if inspired by one motive, and directed by an inner body intelligence, all the communities of the body cells act together to produce a counteracting poison,—a poison which shall destroy the poison manufactured by the disease germs,—Nature's antitoxine.

If the phagocytic defense, united with the cell defense, is sufficient, the disease is overpowered. The patient suffers slightly, recovers.

If not, the patient suffers more severely,—may recover, or not.

The pivotal point, on which the whole matter turns, is the condition of the body. If in good health,—all the organs sound, vigorous, in good working order,—the amount of antitoxine manufactured by the cells, with the help of the phagocytes, is able to neutralize the poison manufactured by the enemy, and the body wins. But if the body is in poor health,—its forces in feeble state, not in good fighting trim,—unless the natural forces are re-enforced, the enemy wins.

CHAPTER LXXXI

NATURE'S ANTITOXIN REINFORCED

IN certain diseases,—diphtheria, scarlet fever, lockjaw,—the germs multiply so rapidly, generate poisons so fast, that the body cells are sometimes unable to manufacture antitoxine soon enough to meet the emergency. More antitoxine is required.

Happily, the way to furnish this extra help is now known, and Nature's antitoxine may be reinforced,—the life of the patient saved.

Of the methods used to procure this help, one only need be considered. In the first place, the germ causing the disease for which the antitoxine is desired, is isolated. A pure culture is next made of the germ. A lower animal is then inoculated with the culture.

In the body of the animal the germs grow, multiply and produce the poison which cause the disease, exactly as they do in the body of the human subject infected by the same germs. With the onset of the disease, too, the cells in the body of the animal go to work,—just as they do in the body of the human subject,—and manufacture a counterpoison, a poison to destroy the poison manufactured by the disease germs.

This counter poison does its proper work. It neutralizes the poison causing the disease. The animal in due time recovers.

At a suitable time after recovery, from the body of the animal a quantity of blood is drawn. It coagulates. The heavy parts sink to the bottom, the serum rises to the surface. It contains germs. It is therefore filtered, sterilized, purified.

This serum is now the real antitoxine, exactly the same in kind and quality with that prepared by the cells in the human body.

It is now ascertained how much of this antitoxine is a proper dose for the child, how much for the adult.

Then, when the child or adult is taken with the disease, the proper dose is immediately administered by hypodermic injection. The dose,—modified, if need be,—is repeated as often as circumstances require. Nature's antitoxine, already set up by the body cells of the patient, is thus reinforced. The combined quantity now in the blood is sufficient to counteract and overpower the poison manufactured by the disease germs. The patient recovers.

This is one of the greatest discoveries in medical science. The treatment is attended with great success. By it thousands of lives are saved. In localities where 60 per cent. of the cases,—diphtheria, for instance,—used to prove fatal, now only 12 per cent. prove fatal. Each one of the twelve, no doubt, could be saved if the antitoxine could be administered at exactly the right moment and in proper doses.

CHAPTER LXXXII

WHAT THE PHYSICIAN CAN DO

HE can assist Nature, and assist only. He can diagnose the disease, and, when required, properly administer the antitoxine. He may direct as to good nursing, sanitation, quarantine. He may vaccinate, use the knife, and comfort the mind with wise counsel, inspiring hope.

Whatever the physician does, in order to be any good, must be done strictly along the lines of Nature. Counter and cross roads are dangerous. Drugs may kill; they never cure.

The case of J. P. Morgan is a world-wide caution. The drug to induce artificial sleep induced the eternal sleep!

The doctor never did, never will, cure his patient. Nature does that. The farmer hoes his corn, Nature alone makes the corn grow.

Sunshine is good for corn. It is good for the sickroom. A smiling face is often the best prescription; a cheerful word the best tonic.

Few and simple are the real duties of the doctor. Highest skill is to know what the few duties are. Highest wisdom to do them. Highest courage to do them only.

The danger is in overdoing. I knew a man in

Grand Rapids, Michigan, who being taken ill, called, one by one, thirteen physicians in twenty-four hours. Each gave a prescription. The next day the man was dead! Is it any wonder? He probably did not need one physician. Thirteen were a dozen and one too many. Grand Rapids is not the only place in the world where, as Scripture has it, one has "suffered many things of many physicians."

Malpractice is practice which should not be practiced at all.

A populous city had the usual number of doctors. One among them was most popular. He had large practice. Almost uniformly his patients recovered. Undertakers complained that he gave them no jobs. Other physicians wondered at the secret of his great success. He alone knew it, and kept it. In practice he gave chiefly bread pills!

The pills were innocent. They had no virtue; but they did not kill. Not to interfere with Nature, is to let Nature cure.

To take medicine gracefully is a fine art,—the finest art, secretly to hide it in the stove.

If seriously ailing, by all means consult a physician. Induce him to tell you all he knows about your ailing. It will not take him long. But do not swallow that which you do not know, and he does not know. A step in the dark may be a step into the grave.

In medicine, guesswork is a crime. No work is infinitely better.

CHAPTER LXXXIII

WANTED — THE UP-TO-DATE PHYSICIAN

DURING the early history of Medicine, there was a time, when the cause of disease was supposed to be the entrance of an evil spirit into the body. Once taking possession, the spirit run the machinery of the body to suit itself. The engine usually jumped the track, sometimes ending in a smash-up.

Curing the patient was removing the cause — casting out the spirit. For this purpose came the "medicine man." He gave the sick one bad tasting and bad smelling drinks. This, he believed, would make it disagreeable to the spirit, and thus cause him to leave. He also made terrific humdrum noises to frighten the spirit away.

Under this treatment, those patients who would have gotten well anyway, recovered. Dr. Medicine Man, with his assumed supernatural powers, received the credit.

At that early day it was recognized that the prevention of disease is practicable, and by those in good health charms were worn to keep away the bad spirits, and thus prevent disease.

At a later time, came the Miracle Cure. The cause of disease was believed to be the same, but the mode of cure had gradually changed. Priest

and doctor were one. Like the medicine man, the priest assumed supernatural powers; but in the place of bad drinks and hum-drum noises he used the fiat of his own will. By his command evil spirits were cast out.

As in the first era, so now, patients destined to pull through got well. The priest had the credit.

At a still later period came the Drug Cure. This cure prevails to-day. The spirit cause has given way to a material cause. The cure is also material. The material machinery of the material body gets out of order, and needs a material drug to repair, oil up, and put it in smoothly running order again. As the disorders are found to be many, drugs have multiplied to endless extent. To compound new medicines, chemistry has been taxed to its utmost. Patent medicines and soothing syrups flood the world. For these alone, it is estimated, the people of the United States pay at least \$100,000,000 every year. One needs a Noah's Ark to float above the ocean of poison!

In this era the doctor is differentiated from the priest. His numbers vie with the quantity of drugs. Medical colleges have been established and multiplied over the earth.

These mills grind out every year, all over the world, each a grist of doctors. In every village of 2,000 people you shall find five or more; of 5,000, twelve or more; of 10,000, thirty or more; in the United States, 125,000 doctors, besides a host of fakirs, pretenders, charlatans.

The doctor traces back his professional genealogy to the sacred priest, and to the sacred medicine man. No wonder, therefore, that popular sentiment still throws around him a kind of sacred halo. The average patient regards the doctor about as the fetich worshiper regards his fetich. The doctor calls. He looks. He deals out drugs. The patient, with bridled tongue, and closed eyes, swallows!

Under this treatment, patients, able by nature to stand it, get well,—often in spite of the treatment. The doctor has the credit.

No slur is here intended. A meager statement of facts,—that's all.

It is all good, natural, necessary. The tree has its evolution; so has the world. And medical knowledge has its evolution. From a simple beginning at some very remote day it has developed, step by step, slowly but surely, through the long centuries, to its present proportions. Still its evolution is far from complete.

Already a new era is in sight. It is Nature Cure. In this new light medical practice, for the first time, rests on a scientific basis.

The cause of disease is no longer guesswork; it is absolutely known. The cure is no longer experiment; it is as well known as the cause. The cause is natural, the cure is natural. The micro-organisms which cause disease are a vital part of Nature. The antitoxines which cure disease are strictly a product of Nature.

The up-to-date physician is one who recognizes this new light, and serves the sick accordingly; adapts the cure to the cause. He doctors the body; he doctors the mind as well. To every patient he explains the nature of the disease which ails him, its cause, its cure, its prevention. To society new light, no less than new health.

Not "some great thing," but all as simple as to "bathe seven times in the river Jordan."

Yet great, because simple. The new physician means new, higher education. Lower grade medical colleges go; the higher, and still higher, come. Fewer colleges, fewer physicians. One physician in the New Era fills the place of five in the Old. To a population of the United States, 25,000. The other 100,000 better serve their country as "the man with the hoe."

The dawn of the New Era in sight, how long before its noonday? No one can tell. But come it must. Evolution goes not backward; always forward. As surely as humdrum noises gave way to Miracle Cure; Miracle Cure to Drug Cure,— so surely will Drug Cure give way to Nature Cure.

PART II

PREVENTION

CHAPTER LXXXIV

VACCINATION AS A PREVENTIVE

THAT every contagious and infectious disease is preventable goes without saying. Yet it has been said over and over again; and it ought to be repeated again and again, to make every one familiar with the fact. Its vital importance warrants repetition in the ears of the world continually. A little thing to prevent the fire from kindling in your house,—a big thing after your house is half burned, to put out the fire and repair the damage.

Prevent the disease before it half destroys the body in which you live.

Each disease may have, in some respects, its special means of prevention; but certain means apply, more or less, to all.

One means is vaccination. This means is natural; and good because it is natural. When in each disease the germs manufacture the poison which is the immediate cause of the disease, all the cells of the body unite in a common effort to manufacture an antitoxine to counteract the poison. As the pa-

tient gets well, the antitoxine, or its effect, remains in the body and protects it against a second attack. The individual therefore has the disease but once. Afterwards he is immune.

Now, it is found that a light form of the disease renders the body immune against the second attack just as effectually as a severe form. Hence a way is discovered to produce the disease in a light form. A bit of the virus is introduced to the circulation by inoculation. The person inoculated has the disease in its light form,—a mere touch of the disease. But this makes him safe against a second attack.

This is vaccination,—Nature's preventive. The entire process is natural. Nature manufactures the virus. Nature produces the mild form of the disease. Nature prevents the recurrence of the disease.

During the hundred and twenty-five years since the discovery of this process by Dr. Jenner, by vaccinating for the smallpox, no doubt, more than a hundred and twenty-five million lives have been saved.

Of course, in case of a disease which comes only in a mild form, like the chicken pox, vaccination is no good. But in case of threatened epidemics of a severe disease, vaccination of those more specially exposed is great good.

For several of the severer diseases vaccines have already been discovered and applied with great success.

In India, the home of the cholera, vaccination for that disease yearly saves the lives of thousands.

Among soldiers in barracks specially exposed to typhoid on account of the drinking water and unsanitary conditions, vaccination for that disease proves a wonderful safeguard.

In threatened epidemics from diphtheria vaccination is equally successful.

At no distant day in the future, vaccines, no doubt, will be discovered for bubonic plague, yellow fever, scarlet fever, measles and whooping cough.

When it is better to use the vaccine than to suffer the disease, should be decided by the physician, — if he is up-to-date and honest.

CHAPTER LXXXV

QUARANTINE AS A PREVENTIVE

FIRE kindles in your building. You sound the alarm. The fire company surrounds the building and there confines the fire until extinguished.

This is quarantine. Unless the building is thus quarantined, the fire may spread and consume a thousand other buildings.

One is taken with disease. The house is guarded. None but doctors and nurses allowed to enter. The guard is kept until the disease is ended and the house disinfected.

This is quarantine. Unless it is enforced, the disease may spread and infect a thousand others. The one quarantined is quite as well off; the thousand are as much better off as health is better than sickness,—it may be, as life is better than death.

Not quarantining the one a few days, may be quarantining the thousand eternally in the grave.

In considering each contagious and infectious disease, quarantine has been urged. It is now, and again, urged for contagious and infectious diseases alike.

Quarantine the child in disease. The adult in disease. However slight the disease, quarantine it all the same,—chicken pox no less than small-

pox. Every disease proves fatal sometimes. You never know how it may end.

Expose the child to disease because it usually comes in light form, and you would "over with it?" It is, in a sense, murder. It may result in death!

Guard the child as much as possible from every disease. Negligence and carelessness are crimes. To be always on the safe side, is the acme of wisdom.

To use quarantine in every community, for all it is worth, is to prevent one-half, or more, of the sickness in the world.

CHAPTER LXXXVI

OFFICIAL PREVENTION

ON health officers, boards of health, rests a deep responsibility. They are the guardians of health. It is their duty to see that the causes which predispose to, and induce, disease have no existence. Their duty, therefore, to prevent nuisances, uncleanliness, unsanitary conditions. In so doing, they prevent disease.

Theirs to see that no water containing disease germs is used for domestic purposes; that no milk tainted with disease germs is used for food.

Theirs to see that all meats and other foods,—baby foods or adult foods,—prepared with chemical poisons, with the view to keep them, are banished from the earth.

Theirs to see that all so-called patent medicines, soothing syrups, syrup of figs, castorias, and other poisonous decoctions, are banished from the light of civilization.

Theirs to see that, in every case of contagious or infectious disease, the house in which it occurs is posted and quarantined; and, when the disease ends, disinfected.

Theirs to guard all ports with quarantine against the importation of disease.

Theirs to see that schoolhouses and other public buildings are kept so clean and sanitary as not to become breeding places of disease.

Theirs to throw such kindly protection over school children that they may not contract disease because they go to school. In the United States 20,000 school children, or more, die every year of the four diseases, diphtheria, scarlet fever, measles and whooping cough.

This slaughter of the innocents is a disgrace to modern civilization.

Wipe it out. Raise and widen the standard of qualification to teach. Require the teacher to pass thorough examination in bacteriology in all its relations to health,—to be able to explain the nature, trace the cause, tell how to prevent every contagious and infectious disease.

Then let the guardians of health see to it that the teacher puts this knowledge into practice in the schoolroom.

By such means may the innocents be spared, and mothers no longer tremble when they send their children to the schoolroom.

All in all, as health officers neglect or faithfully perform duty, so ebbs and flows the tide of health and life.

Shield not inaction with the excuse of underpay. If you cannot afford to act, down and out. It is a matter of life and death. Acceptance demands faithful action, pay or no pay, nothing or a million!

PART III

INDIVIDUAL RESPONSIBILITY

CHAPTER LXXXVII

BE CLEAN

CLEANLINESS is the simplest, yet the most potent preventive of disease. Disease germs starve on Cleanliness; fat on filth. Cleanness repels them; filth attracts them.

Nature abhors filth, and so converts it into green grass, roses, stately trees.

The lower animals in the wild state keep clean, and therefore avoid disease.

Filth and disease are sisters; crime and disease first cousins. They all belong on the same genealogical tree.

Physical purity induces moral purity. A clean body begets a clean mind.

To save the body is to save the soul. The sin of the world is the world's filth. Wash it away, and be clean.

In one's skin are two and one-half million pores, — little tubes, sewers for the outlet of waste from the body. Through this system of sewers worn out material is every moment passing,— usually as in-

visible perspiration; sometimes visible, in the form of sweat drops.

From the body of every adult two quarts of this sewage pass away every twenty-four hours.

It is Nature's method in keeping the body clean —absolutely essential to life and health. Stop up these two and a half million pores on any person, and in three or four hours he is dead,—suffocated and poisoned to death. See to it that they are all kept open by the frequent bath. Soap and warm water do the best job.

The bath keeps away disease, promotes health, and elevates one spiritually.

To be clean is to live in Heaven; to be unclean is to live in Hell.

Angels live in sweetness and purity. Personal cleanliness is an angelic shield warding off many a foe.

A clean house is a heaven on earth; devilish germs keep away.

Clean surroundings are a celestial environment; clean men and women live within.

A clean city would be "paradise regained"; a clean world the "new heavens and the new earth wherein dwelleth" Health and Happiness.

CHAPTER LXXXVIII

BREATHE CLEAN AIR

ONE breathes into his lungs about 300 cubic feet of air every twenty-four hours; and exhales from the lungs, in the same time, the same amount of carbonic acid and watery vapor.

The whole population of the world breathes, during every twenty-four hours, about four hundred and fifty billion cubic feet of air, and exhales from the lungs the same amount of carbonic acid and watery vapor.

To breathe is to live; not to breathe is to die. One not breathing for three minutes is dead. Stop the whole population of the earth from breathing three minutes, and not one lives to tell the story.

The oxygen of the air breathed into the lungs purifies the blood and keeps burning all the fires of life. The carbonic acid thrown out is a deadly poison. To breathe it over is death.

But Nature is not willing that her children should breathe poison; she therefore keeps her atmosphere pure. As fast as the billions of gallons of the acid are poured into the atmosphere, the vegetable world seizes it, picks it all out, and devours it as food. The atmosphere is thus always kept clean and sweet for man and beast.

But one may take into his system the tiniest speck of any kind of poison with no harm — sometimes perhaps with good.

Hence Nature allows her atmosphere to contain everywhere the tiny speck of carbonic acid. Of air in its normal condition $\frac{1}{70}$ of one per cent. is carbonic acid. This tiny amount of poison does no harm; it may do good.

But this is Nature's limit. To increase the per cent. of acid is danger. One per cent. is decidedly against health. Ten per cent. is fatal,— it kills.

Look at Fig. 110. The paper box contains thirty cubic feet of air. It fits closely around the neck, and is air tight. From without no air can come in; from within none can go out.

The first breath of the man takes from the box twenty cubic inches of good air, and throws back into the box the same amount of carbonic acid and watery vapor. All the air in the box is thus tainted. Every succeeding breath taints it more and more, until the man has nothing to breathe but poison. In twenty minutes he is dead — suffocated and poisoned by bad air.

An English fort in Calcutta was garrisoned by 146 English soldiers. The Indian captain captured the fort, and chucked the soldiers into a dungeon for the night. The dungeon was 18 feet square, with two small windows. At the end of eight hours the captain, returning to the fort, found 123 of the soldiers dead, and the others no better than dead — suffocated and poisoned by bad air.

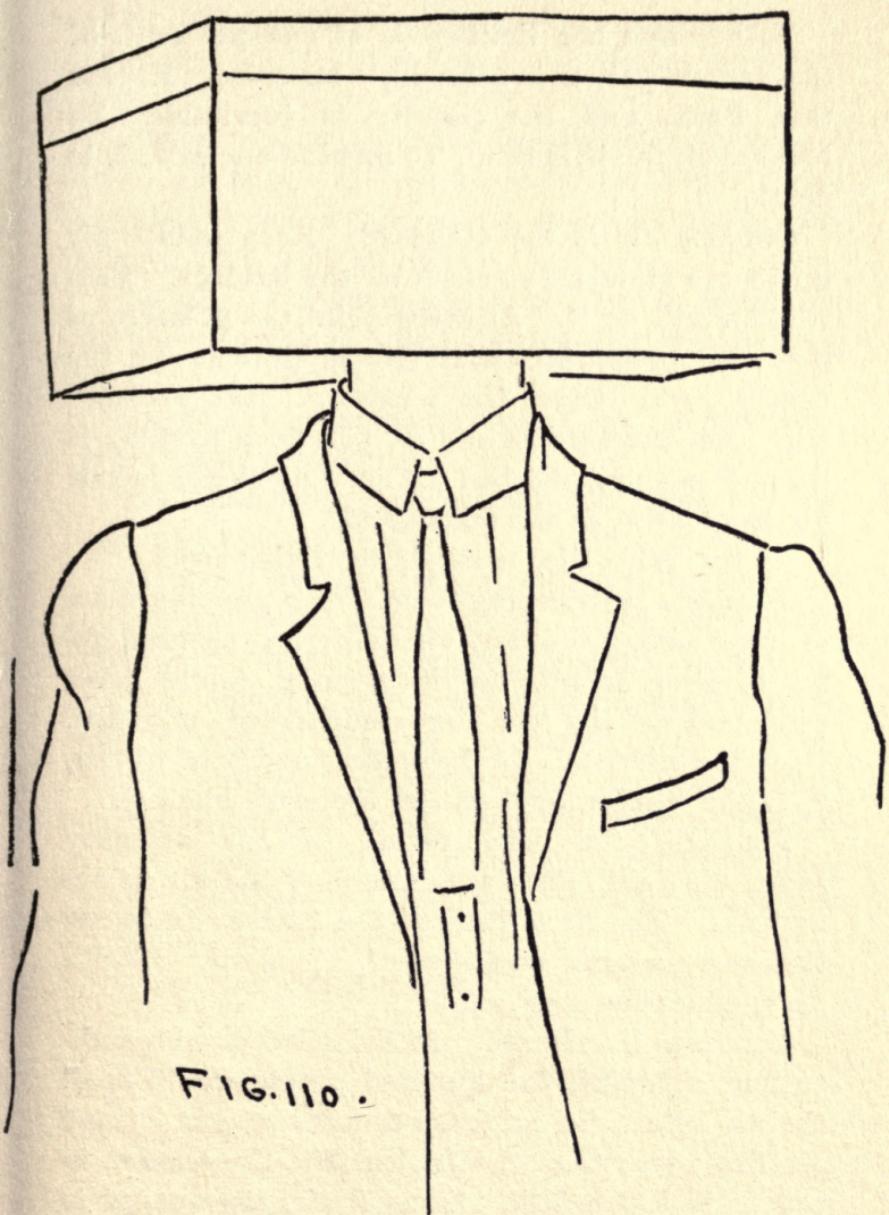


FIG. 110.

Nature sets her limit — $\frac{1}{70}$ of one per cent. of the carbon poison is allowed,— no more. Exceed that limit, and the penalty is inevitable. To breathe clean air is life. To breathe unclean air is death.

Outdoor air is the standard. Keep indoor air up to the standard — clean as the outdoor. Ventilation will do it. At every point the pressure of the atmosphere is about fifteen pounds to the square inch. Open the window. That pressure will push the outdoor air in, and keep pushing it in, and pushing the bad air out, until the indoor air is as clean as the outdoor air.

As you value life, ventilate the living room.

Ventilate the sleeping room. In a sleeping room of usual size, absolutely air-tight, two persons, going to sleep at nine in the evening, would never awake to see the sun rise — suffocated, poisoned. Open the window. In the coldest nights of winter, open the window, and put on the extra blanket.

Ventilate the schoolroom. In the ordinary room, air-tight, sixty scholars spoil the air in six minutes. The first duty of the teacher is to see that every scholar breathes only clean air. Health first; education next.

Ventilate the church. In the usual church auditorium, air-tight, five hundred people would spoil the air before the minister finishes prayer. Good air first; prayer next. In bad air, the answer to prayer is bad health. In good air, the answer is good health. The best answer which could ever be

given to prayer is good health. Seek first the Kingdom of Health. On it all things good are built.

Always and everywhere breathe clean air, and clean air only. It will keep the blood pure, give stamina to nerve and muscle, prevent disease, promote health, prolong life.

Devote a few moments every day to breathing deeply. Let every breath expand the lungs to their utmost.

Spend a few moments every day in breathing rapidly and forcibly.

When weary or worried, such exercises rest the body, renew the mind.

Suppose every one, the world over, were obliged to pay for the air he breathes,—a certain price per hundred cubic feet. Suppose, too, the Powers who deal it out should, at times, adulterate the air. What kicking! Kicking, the world over!

Then, while Nature furnishes to every one a thousand times more air than is needed, and cleanest in quality, will you still breathe adulterated air? Will you, by your own act, adulterate it? And then breathe it?

If so, kick yourself!

CHAPTER LXXXIX

Woo THE SUNLIGHT

IT comes from a ball of fire 81,000 miles in diameter, 2,700,000 miles in circumference, 1,300,000 times as large as Earth. Of this fire is born the Solar System. The eight planets are the Sun's children; the retinue of moons revolving around them, his grandchildren; the hundreds of comets, the thousands of clouds and streams of meteors, the by-products resulting from the evolution of his Family.

Weigh this ball of fire; it tips the scale at 2,000,000,000,000,000,000,000,000 tons — two octillion, 750 times as much as the weight of all the planets and moons combined. Its pull on the Earth by gravity is 3,600,000,000,000,000,000 tons — three quintillion six hundred quartillion. A man weighing 150 pounds on Earth, would weigh on the Sun two tons. He couldn't stir.

Pile 1,900 pounds of anthracite coal on each square foot of the Sun's area. The layer surrounds the Sun at every point sixteen feet thick. Burn its every atom in one hour. The amount of heat generated equals only the amount of heat radiated from the Sun's surface every hour.

At 93,000,000 miles away, the Sun's heat is yet sufficient, at the equator, to melt a layer of ice 110

feet thick every year. At the distance of our moon, 240,000 miles away, its heat would flash the earth into gas.

We live in a fast age — the fast auto, fast trotter, fast everything. But to make the run from Earth to Sun, the fastest auto, at sixty miles an hour, without stopping, requires 175 years. The Kentuckian trotter which has just broken the world's record at $2:3\frac{1}{4}$, to trot from Earth to Sun at the same speed without stopping, requires about 360 years. Yet the Sunlight starting this moment from the Sun, bounding on the waves of Ether, at the speed of 196,000 miles per second, will reach you and perhaps be the light in which you will be reading before you finish this chapter.

And what light! 1,575,000,000,000,000,000,000,000 — one octillion five hundred and seventy-five septillion — candle power. The brightest light which can be made by Man, interposed between the eye and the Sun, is a black spot on the Sun.

Sunlight coming from such a wonderful ball of fire, at such wonderful speed, so wonderfully bright, no wonder its work is wonderful. Radiating with every ray of heat from every point of the Sun's area, it is, in a sense, equal in quantity to the quantity of heat. Divide the sum total by 2,200,000,000. Earth catches only one of these parts, the one two billion two hundred millionth part of the whole. The rest is intercepted by other worlds, or lost in the abysses of infinite space.

Yet what magic power this minute fraction. It

makes possible all the snows and rains which annually fertilize, refresh and renovate the earth. It makes possible all the springs, rivers, seas, oceans. It makes possible all vegetable and animal life. Shut off the Sun's light and heat from the earth, and in three days all life on the earth is extinguished.

His smile is life. He smiles in Spring, and the vast sheets of ice and snow disappear like magic. He smiles again, and the earth is covered with green. Again he smiles, and the earth is crowned with flowers perfuming the air with fragrance. Once more he smiles, and the earth is loaded with the ripe fruits of Autumn.

In his smile all animal life is made glad. In Sunlight basks the tiny insect. In Sunlight "cattle feed on a thousand hills." In Sunlight all mankind "live, move and have their being." "'Tis mighty in the mightiest." "God is a Sun."

Woo the Sunlight. Life and Joy to the world, it is life and joy to body and mind alike. Sunlight is the mind's good cheer, the mind's good health. The "blues" are mental dyspepsia; Sunlight chases them away. Fear and doubt are mental clouds; Sunlight dispels them. The coward is born of the night; Sunlight makes the hero. Crime, like the mushroom, grows in darkness; virtue, like the rose, in Sunlight.

Woo the Sunlight. It is the body's best tonic, the body's best guard; muscle to muscle, nerve to nerve, brain to brain — a better shield than the shield of

Achilles. That protected its hero all but his heel; this protects head, heel and all between.

It does more; it fights our battles, it kills our deadliest foes. Here is the vital point—the point to be made most pointed. Mighty to give life, Sunlight is mighty to give death—death to the very foes most dreaded. It kills the microbes of tuberculosis in three hours; of typhoid, diphtheria, scarlatina and others, nearly as quickly. These deadliest foes hate the light. They hide in the soil. They lurk in the water. They steal into the darker recesses of the body. “They choose darkness rather than light because their deeds are evil.”

Woo the Sunlight, it will dash these foes from your door. The world’s best protector, let it protect you. The world’s best doctor, let it doctor you. The world’s best energizer, let it energize you.

Woo the Sunlight; it is the beau ideal, the sweetest sweetheart in the universe. Sunlight kisses the shower—the rainbow is on the cloud; kisses the lily—it blooms in pure white; kisses the peach and the rose—they blush in beauty; kisses the forests—they dress in living green; kisses them again—they appear in all the golden tinges of autumnal glory; kisses the bodily frame—sinews gain new vigor, limbs grow plump, cheeks glow with the bloom of health.

Bathe in the Sunlight. Walk in the Sunlight. Work in the Sunlight. Play in the Sunlight. Roll up the curtains, let in the Sunlight. It sterilizes your rooms, sweetens your home, makes glad your heart.

CHAPTER XC

DRINK CLEAN WATER

THREE-FOURTHS of the earth is covered by water. Three-fourths of every vegetable on the earth is water. Three-fourths of every animal, including man, is water.

To support this general seventy-five per cent. of water requires a vast annual rainfall. Nature is ready with her supply. A body of water equal to a sea three thousand miles wide, sixteen feet deep, and twenty-four thousand miles long, falls on the earth every year.

One portion of this water feeds all the rivers and other streams, which finally find their way to the sea, helping keep up the sea level. The other portion, after feeding the vegetable and animal kingdoms, sinks down deeply into the earth to feed all the springs and underground currents.

The first portion, when used by man, is called Surface water; the second, Spring water. Which the clean water?

Manifestly Surface water is exceedingly liable to contamination. The chances are manifold. Every heavy rain washes into streams, lakes and ponds, from adjacent lands, all sorts of impurities. Into all this Surface water careless persons dump

nuisances galore. Into this water sewage from country houses, villages, cities, finds its way. Into this water disease germs from infected localities are sure to come.

Surface water is therefore always more or less unclean, unsafe.

On the other hand, Spring water is practically clean, safe. As it falls from the clouds, and sinks down into the earth, it is filtered through strata of sand, gravel, rocks, and is thus made clean.

Deep Artesian water is filtered the best, and is the cleanest water in the world.

But water from common springs,—when the springs are properly developed, and the surroundings kept clean,—is excellent and safe.

Typhoid fever and cholera are almost invariably traceable to the use of Surface water. In the same way diphtheria, tuberculosis, and some other diseases are often communicated.

By all means, when possible, drink only Spring water. When not possible, before drinking Surface water, boil and thus sterilize it.

Use not the open well. It is always dangerous. You know not when nor how much pollution may get into it. You may say that you have used the open well for a long time and it has always been safe. But how do you know it has been safe? Have you ever been ill? Any member of your family ill? May not the illness have come from the well? If no harm yet, how long before harm may come?

Anyway, the open well is unsafe. How liable to pollution. Toadstools may grow on its curbing, fall and poison the water. Small animals—mouse, mole, snake, skunk, rabbit,—may fall in and decay!

If you must use the open well, cover it tightly, clean often. But remember the drive well is a hundredfold safer. If deep enough, all pollution is avoided.

In developing the spring, dig deep—to the bed rock if practicable. Lay the pipe, with copper strainer attached to end. Curb with small stone and Portland cement in such way as to exclude all surface water. Build the curbing two feet above surface ground. Bank it around. Put on roof with locked door. You thus get only the pure Spring water.

CHAPTER XCI

EAT CLEAN FOOD

Food to the body is what fuel is to the steam engine. It furnishes the power which runs the entire body machinery.

Quality, therefore, not kind, counts. Good, dry, solid fuel, of whatever kind,— wood, coal, gas, electricity,— makes the hot fire which impels the engine. Good, clean, nourishing food, of whatever kind, makes the chemical fire in the stomach that furnishes power to the body.

The ultimate chemical elements of all kinds of food usually eaten, vegetable or animal, are about the same. Don't be fussy about the kind. The essential thing is that food be well cooked, clean, wholesome.

Decayed fuel is no good to run the engine. Its heating properties are insufficient. Decayed food is worse still. It is poison, running the body off the track, into the grave.

A tainted can of salmon wrecks a whole family.

Ptomaine poisoning from other canned goods,— meats, vegetables galore,— is certainly not out of fashion.

After the Civil War was over, investigation showed that the embalmed beef used as rations was

more dangerous to our boys in blue than the bullets of the enemy.

Embalmed breakfast foods are money to the embalmers,— slow poison to the consumers.

The other morning I tried a couple of boxes of corn flakes for breakfast. They vanished like thin air,— nothing to show for them.

At ten cents a box, I estimate that a bushel of corn, puffed up into these flakes, brings the puffer twenty-four dollars.

On corn, I can feed my rooster at one cent a day; and he grows fat. On flakes it would cost me twenty times as much per day; and I fear he would grow poor at that!

Go, ye blown up flakes invented by money sharks; come ye delicious Johnny cakes invented by grandmothers.

Its mother could not nurse my baby. The doctor ordered prepared baby food,— one teaspoonful mixed with water every two hours by the kitchen clock. Not enough to keep a young robin alive! Much less a ten-pound baby!

For two weeks my baby was crying most of the time — starving all the time. Lost two pounds — one pound a week.

I armed for fight. A big rebellion! Discharged doctor. Ordered clean Jersey milk. Fed lightly two days,— then all baby would eat. Not by two-hour-kitchen-clock, but by baby-stomach-clock. Jersey food always ready when baby stomach

hungry,— once in two hours, or once in two minutes.

Crying turned into laughing; waking into sleeping; starving into growing. Baby gained a pound every week.

That baby is now four years old. Takes the Jersey bottle just as when four weeks old. The very picture of health.

I decree that all baby stuffs, breakfast stuffs, be used forthwith to heat up the hottest hell ten times hotter than usual for the doom of all the sharks and embalmers.

Home-made food is the stuff. Jersey milk for children. For youth and adults, what you like, and all you want. Thank Nature for appetite. It is the best guide. For age, such food as can be masticated without false teeth.

Cook well. Eat no raw beef; it may contain germs of tuberculosis.

No raw pork; it may contain cysts of the tape-worm.

No raw oysters; they may contain typhoid germs.

If milk or water is suspicious, cook the suspicion out of it; make it clean.

Masticate well. The mouth is the mill in which to grind the food. Grind it fine. Swallow nothing until ground to liquid.

Bolt your food, like the dog, and dyspepsia will soon dog you.

Don't hurry. Time well spent at the table is

worth more than all other time. Prolong it. Always do a good job.

Eat only clean food, and enough of it, and the joy of youth will smile in age.

CHAPTER XCII

BE TEMPERATE

To get drunk is to surrender oneself to the mercy of his invisible foes. The millions of white corpuscles of the blood are the body's standing army. Their duty is to defend the body against disease germs. They devour the germs. But, when the body is drunk, the standing army is also drunk, and the drunken army is already conquered. Unopposed, the disease germs easily find their way into the body, and generate the poison that kills.

But where are the billions of the red corpuscles of the blood? It is their office to generate anti-toxine to counteract this poison. But when the body is drunk, they too are drunk. The poison, therefore, has its way, and permeates the entire system.

The drunken body is utterly defenseless.

Hence the record: When cholera attacks the drunkard, he dies. When smallpox attacks the drunkard, he dies. When typhoid fever attacks the drunkard, he dies. When pneumonia attacks the drunkard, he dies. When the grippe attacks the drunkard, he dies.

Such, the world over, is the handwriting on the wall!

Yet alcohol is one of the best things in the world. In a thousand ways it does good. Without it, what a void! The world would have a paralytic shock.

As a servant, alcohol serves well; as a master, how terrible!

Fire, too, is one of the best things in the world. Essential at every point in civilization. Without it, the world could not go forward a step—only backward. As a servant, how beautiful. As a master, how fearful,—the great city in ashes!

The world over, drunkards are ash heaps.

Let not hell-fire burn soul and body to ashes. Stand upright. Be a man. Be not a slave. Be free. Control self. Victory over self is the greatest victory.

He who wins temperance in the face of all temptation is a hero,—not the hero whose name is blazoned before the world, but that greater hero who bravely conquers the enemy in the quiet of every day life.

In all the relations of life temperance is a vital necessity. With it, life is worth living. Without it, life is worse than dying.

Temperance lies at the foundation of everything good, true and beautiful in life. It arms the body against disease. It keeps the blood corpuscles and all the other natural forces healthful and sound, ready to ward off all invisible foes.

Temperance gives stamina to muscle and nerve,

and is a chief factor in developing all the powers of mind.

Without temperance, the young man is a wreck, and has nothing to hope for. With temperance, the young man is well anchored, in the haven of safety, and has before him all the possibilities of life.

Drunkenness is disgrace; temperance a crown of glory. As you value health, life, success, honor, be temperate.

CHAPTER XCIII

CREMATE THE DEAD

RIGHTFULLY caring for the living is rightfully caring for the dead — so disposing of the dead as to leave no trace of danger to the living.

The usual disposal of the dead,— by interment in city cemetery or country graveyard,— is, in two ways, unsafe.

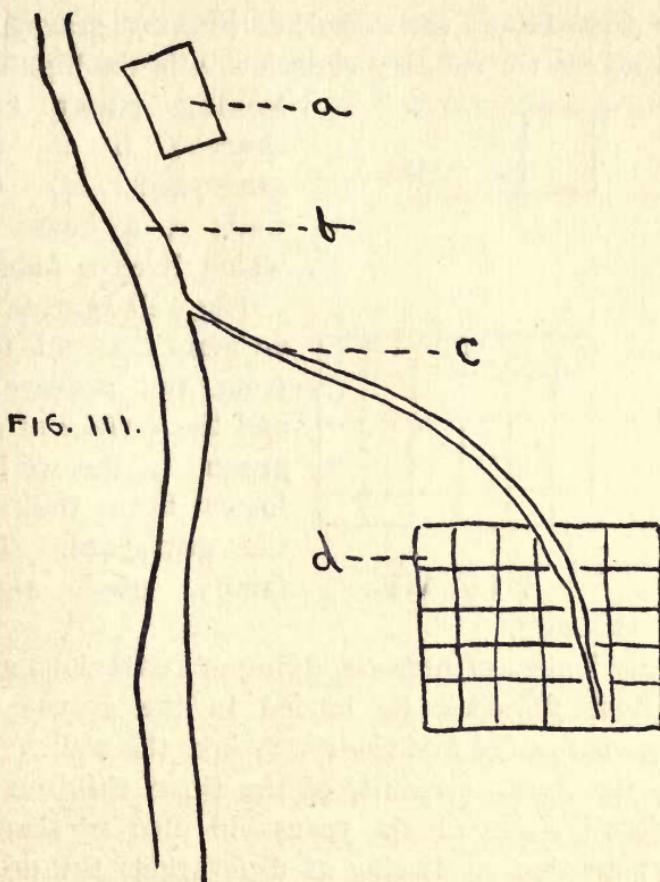
First, poison or germs from the decaying bodies may find their way by subsoil drainage to water supplies. Not unfrequently the burial place is an elevated plane near a stream. The subsoil drainage flows into the stream.

Farther down the stream,— it may be a few rods or a few miles,—is an intake pipe supplying water to a city. The danger is evident.

In Fig. 111 a represents the cemetery; b the stream; c the intake pipe; d the city.

The cemetery is near the bank of the stream, and higher than the stream. By subsoil drainage the poison or germs from the decaying bodies in the cemetery pollute the water of the stream; and the polluted water, finding its way into the intake pipe, produces disease among its users in the city.

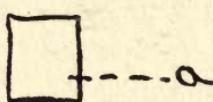
Country places of burial, also, are too often so situated as to contaminate wells and springs. The



following examples come under my personal observation:

In Fig. 112 a is a graveyard containing hundreds of burials; b is a village. The graveyard is seventy-five feet or more higher than the village, and only a few rods from it. Hundreds of families in the village use water, each from a well. It is manifest that the wells are only too easily contaminated by subsoil drainage from the graveyard.

In Fig. 113 is seen another country graveyard situated near a country church. A is the highway



leading past the church; b is the graveyard; d, the well; e, a house in which lives a family.

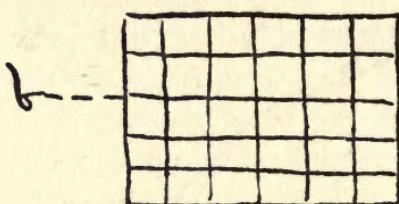


FIG. 112

from the well.

Many bodies of persons, dying of contagious and infectious diseases, lie buried in the graveyard. The germs easily find their way into the well.

As the natural result, of the three children in the family, one at six years old died of scarlet fever; another at twelve of diphtheria; the other at seventeen of tuberculosis. Soon after, the mother died also of tuberculosis.

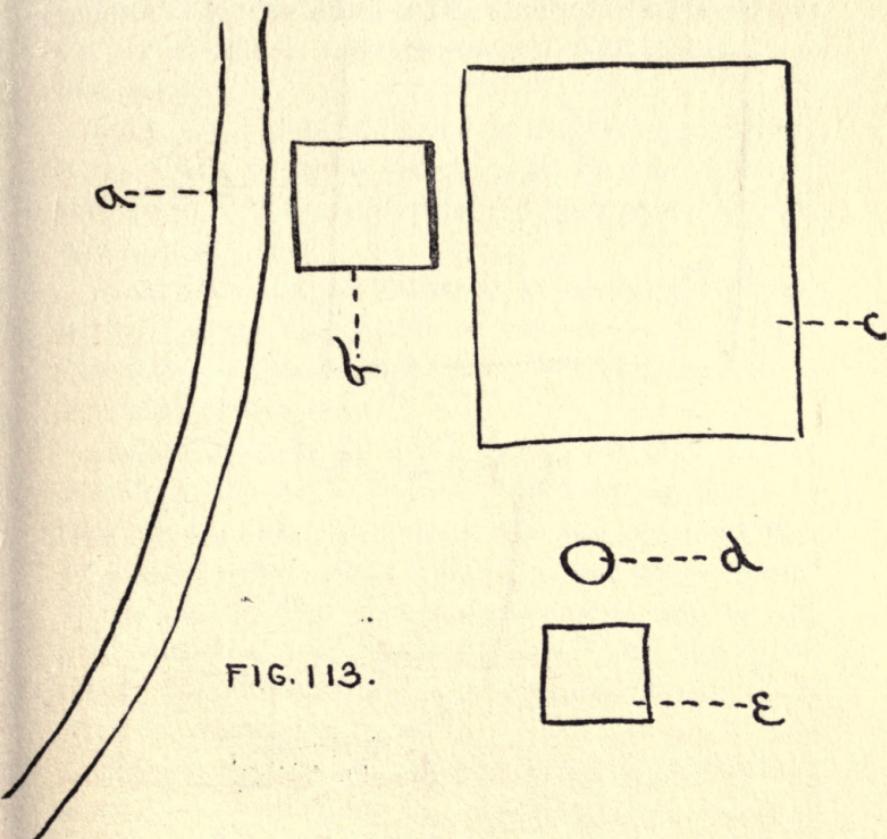
The widowed father married a second wife, who ere long died of cancer. Finally the father died of typhoid fever.

There cannot be a shadow of doubt that this family was wiped out by germs communicated to the well from the graveyard.

Besides, the pulpit of that church during wor-

CREMATE THE DEAD

ship was usually supplied with a pitcher of water from that "old open bucket." People, also, attending worship, especially in summer time, quenched



their thirst from the same source. How many fatalities, therefore, in the surrounding community might owe their origin to that deadly well no one may know.

In Fig. 114 is another example. A is a grave-

yard; b a spring; c a water pipe conveying water from the spring to the seminary of learning, d.

About 300 students attend the school. Among

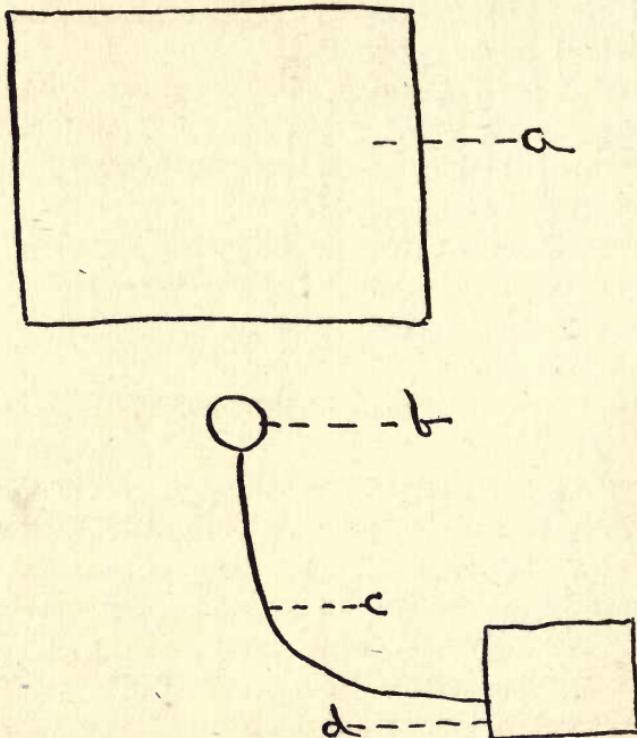


FIG. 114.

them every term is much sickness, with an occasional death.

At length suspicion rests on the water. The spring is about three-quarters of a mile from the school, on much higher ground. On still higher ground, about twenty yards above the spring, is

the graveyard. By examination it is found that the water of the spring is poisoned by subsoil drainage from the graveyard. Hence the mischief.

The water is abandoned, a new and wholesome supply obtained, with the result that the sickness disappears.

Such examples might be multiplied to any extent. They probably exist, more or less, all over the world. The magnitude of the danger incurred is not easily told.

A similar danger, incident to all burial places, springs from the gases of the decaying bodies. These gases rise to the surface, escape into the air, and may be breathed.

Pasteur buried the bodies of sheep that died of splenic fever, six feet deep. Around the grave he erected a small enclosure. Within the enclosure he placed a well sheep which had not been exposed to the fever. The well sheep was soon infected by the germs that rose to the surface in the gases, and died. The experiment was repeated many times with the same result.

The French scientist made these experiments to show the great need of cremating the bodies of sheep, or other animals, dying of this fever. Burying the bodies in pastures, or places frequented by the well animals, was exposing the well animals to the disease, and a sure means of spreading it. But burning the bodies killed all germs, prevented all danger.

But exactly the same conditions prevail with hu-

man burials. Though the burials are six feet deep, the gases are sure to rise to the surface. If death is caused by contagious and infectious diseases, the germs, rising in the gases, are liable to spread the disease. To visit such graves is to walk in danger. Many an epidemic, no doubt, springs from graveyard and cemetery.

To cremate the dead is to save the living from all this danger. From the sanitary point of view, therefore, it is infinitely to be preferred. Could we understand it rightly, too, it would be equally preferred from every other point of view.

The chemical change through which the body passes is precisely the same in the furnace as in the grave. In each case it is the oxygen of the atmosphere uniting with the carbon of the body, producing carbon dioxide which, in turn, goes to feed the vegetable world. In the grave the change requires years; in the furnace, but a few moments. The one fire is slow, the other quick.

The furnace, being a million times the better analytical chemist, is a million times to be preferred. Dissolution into the original elements almost instantly is so much nicer than long years of "moldering in the grave"!

A single cremation now costs about \$40.00. Were the practice universal, it would cost but \$2.50.

Happily, crematories are multiplying. The tombstone must go, the photo remain. Commit the body to the undertaker; he will do the rest.

CHAPTER XCIV

SELF TO CARE FOR SELF

BUT the court of last resort is self. After all outside help is furnished, the final decision,— disease or no disease, health or no health,— rests with you, individual.

It is for you to say whether you will be personally clean.

It is for you to say whether your house shall be clean — whether every filthy fly shall be kept out.

It is yours to say whether the surroundings of your home shall be clean.

It is for you to say whether you will act well your part in keeping town and city clean.

It is for you to say whether you will breathe clean air.

For you to say whether you will woo the sunshine.

For you to say whether you will drink clean water.

For you to say whether you will eat clean food.

For you to say whether you will be temperate.

For you to say whether you will cremate the dead.

For you to say whether you will make your home that which, in a sense it should be — a sanatorium.

You, physician, for you to say whether you will carry the invisible foe from house to house.

You, surgeon, for you to say whether an infected knife shall complicate the disease with another disease.

You, health officer, for you to say whether you will prevent nuisances and draw taut the quarantine.

For each and all to say whether epidemics shall sweep away thousands, or whether epidemics themselves shall be swept away.

If each grain of sand acts well its part, the sea-shore is well.

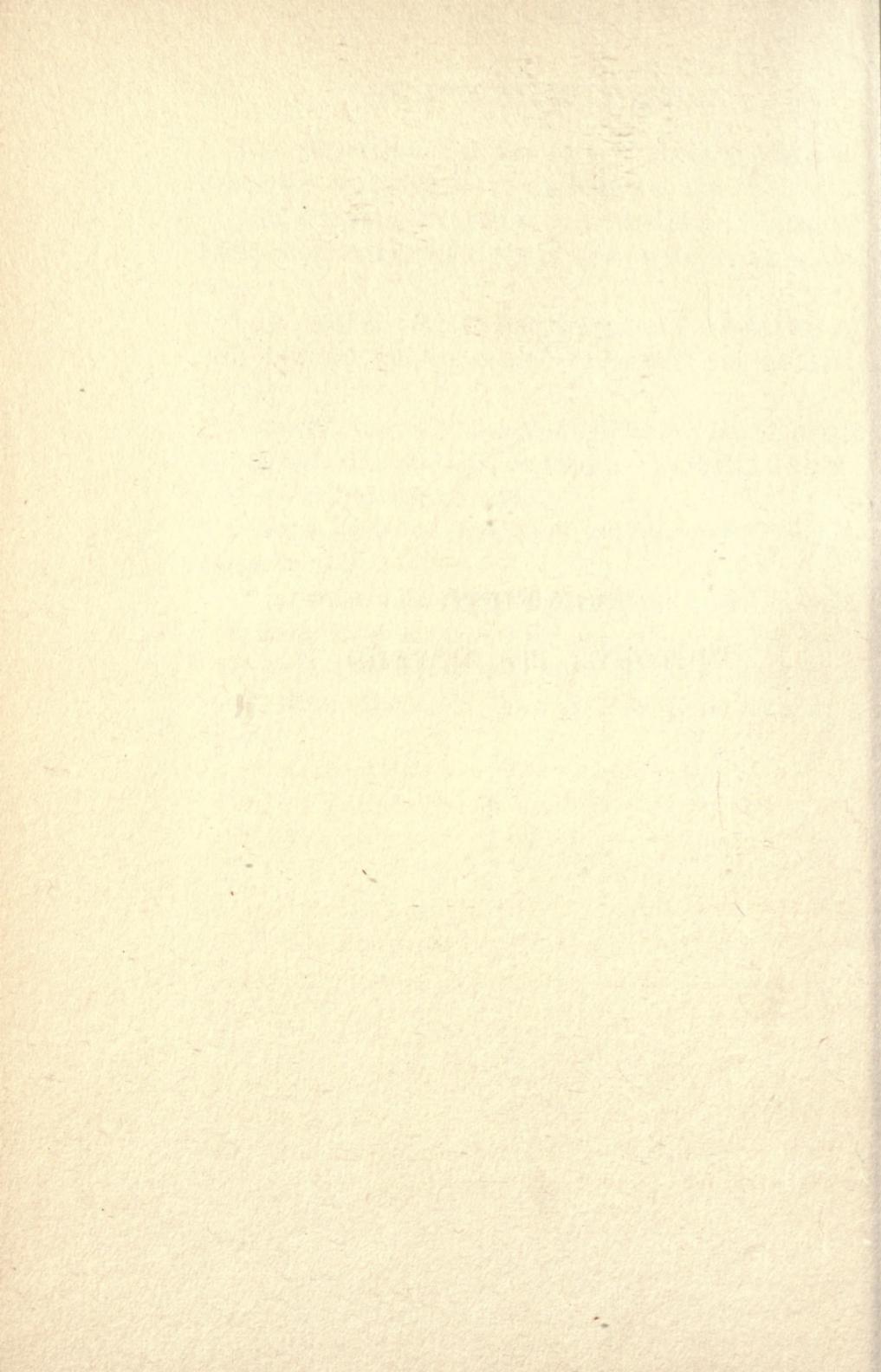
If each drop acts well its part, the ocean is well.

If each atom acts well its part, the world is well.

If each individual acts well his part, disease is swept from the earth, and the world of humanity is well.

BOOK FIFTH

VICTORY — ITS REWARD



PART I VICTORY

CHAPTER XCV

CERTAINTIES

It is certain that, during the last half century, a New Era has dawned in the history of medicine,—discovery of the Germ Theory of Disease.

Certain it is that this theory has become an established fact,—forty-four diseases, forty-four different kinds of germs, one kind of germ the cause of each disease.

Certain it is that a number of antitoxins have been discovered to cure a corresponding number of these diseases,—each antitoxin a specific for each disease.

Certain it is that, if the antitoxin is rightly and timely administered, the disease is cured.

Certain it is that the diseases, thus cured, rank among the worst,—diphtheria, scarlet fever, lock-jaw.

Certain it is that a number of vaccines have been discovered to prevent the same number of diseases.

Certain it is that, if the vaccine is timely and rightly applied, it prevents the disease.

Certain it is that among the diseases, thus prevented, rank some of the worst,—smallpox, cholera, typhoid fever.

Certain it is that, during the half century, great progress has been made in knowing the value of, and how to enforce, the quarantine.

Certain it is that, if all contagious and infectious diseases could be properly quarantined, they would be prevented from spreading, and thus all epidemics prevented.

Certain it is that during the half century great progress has been made in understanding and instituting sanitary measures.

Certain it is that in proportion as such measures are generally used, they serve to prevent all diseases, and so to promote the general health.

Certain it is, therefore, that, with the incoming of the New Era, medical practice is placed, to a large extent and for the first time, upon a scientific basis. The cause of all contagious and infectious diseases are known to be poisons generated in the body by germs. In so far as antitoxins have been discovered, the up-to-date physician knows exactly what to do: By timely administering the antitoxin the poison is counteracted; the patient recovers. The cause is removed; the disease is cured. No guesswork. No experiment. Only scientific certainty.

Certain it is, also, that the knowledge, which has brought about this New Era, is beginning to spread among the people. The original investigators have

published the results of their researches and sent them broadcast over the world. People everywhere are awaking to the new light, beginning to think, understand, act.

CHAPTER XCVI

PROBABILITIES

STANDING on this platform of certainties, one looks forward with great hope. Such achievements, attained during the last half century, make the coming half century bright with promise. The probabilities are that progress along the lines of research will move faster in the second half century of the New Era, and at its end, will well-nigh, if not quite, reach perfection.

All disease germs, which have not already been isolated, will, by that time, be isolated, cultures made of them, their habits made known; and known, it will be, how to control them.

For all the diseases for which antitoxins have not already been found, antitoxins will, by that time, be found, with the knowledge how to use them, and thus how to cure the diseases.

Vaccines will have been discovered to prevent all diseases against which it is desirable to vaccinate, and will be administered.

Quarantine will have been carried to such completeness as to prevent every contagious and infectious disease from spreading,—no epidemic allowed.

The principles of sanitation, too, will have be-

come so generally understood and appreciated, that people, generally, will gladly conform to its requirements, in order to enjoy its great benefits in preventing disease and promoting health.

All these achievements, and many more, during the next half century, will, in all probability, have been fully attained. The required knowledge is already far advanced among the learned, and is fast gaining ground among the unlearned. It is rapidly spreading through the cities. In due time it will reach the rural districts. The conquest will be complete.

The means for the general diffusion of this knowledge are already beginning, in good measure, to be set in motion. For instance, a National Association for the cure and prevention of tuberculosis is already doing a great work. It sends literature everywhere, containing directions how to make the conquest of this disease. It has appointed the last Sunday in April as Tuberculosis Sunday, calling on every clergyman in the United States to use that day in preaching to his congregation on tuberculosis. This is acting as a strong incentive to all the thousands of preachers throughout the country thoroughly to post themselves on this disease, in order to pass along the light to the people.

The Red Cross is doing an equally good work.

The Sanatorium is doing a still greater work. Its light is inciting the people to make a Sanatorium of the home.

The cure, too, is coming. Koch failed. Friedmann is on trial. Final success is near.

By such means, no doubt, within fifty years the people generally may become so well educated on this subject, as to bring tuberculosis under complete control.

And if this, the most destructive of all diseases, can be controlled in that time, certainly it would seem all others can be. To this end other and sufficient means will be invoked.

Our public schools will soon take hold of this work,—teach the scholars the nature of these diseases, how to prevent them, how to keep healthful. Physical culture must come to the front. Every scholar in school, every student in college, will be so educated that he will know how to keep out of disease as well as he knows how to keep out of fire. In the near future, all teachers in our public schools will be required to pass a rigid examination in bacteriology, especially in that part pertaining to disease germs.

Missionary clubs will also, no doubt, be formed in city and country, to reach those people directly who cannot so easily be reached by other means,—to teach them cleanliness, sanitation, and how generally to avoid disease.

Possibly the thousands of dollars now crossing the ocean to change the religious belief of some foreign people into some other religious belief will be turned into channels of higher usefulness at home,—to enlighten the unenlightened in securing

better homes, being better fed, better clothed, better educated, thus avoiding disease and living on a higher plane of life.

All governments, too, during the next half century, will, no doubt, issue a proclamation of universal peace, and turn their guns against the Invisible Foe.

Anyway, seeing what has been accomplished along this line during the last three or four decades, it is only reasonable to conclude that, during the next five decades the command of the whole situation will be complete.

Progress goes not backward. Beginning on any one line, it steadily goes forward, gathering more energy, spreading wider, striking deeper, onward and onward to the destined goal. Within the memory of many men now living dawned on the world the great Germ Theory of Disease. This great Theory the world over has become a great Fact. The world over this great Fact is absorbing the minds of many of the foremost Thinkers of the age, and spreading its light among the people everywhere; so that many men of to-day will live to see knowledge lighting up, the world over, this entire field of Our Friends and Foes of the Invisible World as the noonday sun lights up the Earth.

CHAPTER XCVII

POSSIBILITIES

WHAT, then, are the possibilities? Having acquired the required knowledge during the coming half century, possible it is to make such application of this knowledge during the succeeding half century as to conquer the last invisible foe. Possible it is that in one century from to-day every contagious and infectious disease will be swept from the earth.

Knowledge will do it. Knowledge does everything that is good for the world. Every step in the world's progress is taken by knowledge. Every discovery, every invention is the gift of knowledge.

Knowledge gave us the alphabet, the multiplication table. Knowledge gave the world the printing press, gunpowder, the cotton gin. Knowledge gave the world the locomotive, the telegraph, the telephone.

To knowledge the world is indebted for all the machinery used in all the industries of modern life.

First, the knowledge; then what knowledge does. Such is the Order, and such the Order only, from the brain of the Ape to the brain of Newton.

First, the knowledge how to conquer, prevent, extinguish every contagious and infectious disease; then that which this knowledge does,—victory complete over all our Invisible Foes.

This is no wild dream of a mere visionary; it is based on solid facts. The rapid strides along this line during the last fifty years warrant all that is here predicted,—the world's greatest battle fought to a finish!

All difficulties leading to war must soon be settled by arbitration. Then, backed by all that war now costs, turn all the guns of all the nations on the world's Invisible Foes, and our most sanguine hopes are realized.

The great Law of Evolution demands it. First, the acorn; then the full grown oak. First, the egg; then the proud eagle on the floor of the sky.

First, the dugout; then the great steamer, the car, the auto, the aeroplane. First, the electric kite; then all that electricity does for the world.

First, the discovery of the Invisible Foe; then the War of Conquest crowned with Victory Complete.

PART II

REWARD

CHAPTER XCVIII

HEALTH REWARD

PROPORTIONATELY great is this reward to the victory achieved. Thirty millions every year dead of contagious and infectious diseases — Victory means every year saving thirty millions from thirty million graves. Accord a score of mourners to each death — six hundred million mourners every year. Victory means all this mourning turned into joy and gladness.

Thirty millions more every year sick and suffering with these diseases, yet finally recovering — victory means exchanging all this sickness and suffering into the glory of health and the joy of duty well done. Health to the individual is the basis of all success and happiness. To the world, the basis of all progress, the highest good, the choicest boon. Victory means this world wide success, this world wide happiness, this world wide boon.

CHAPTER XCIX

MONEY REWARD

CONTAGIOUS and infectious diseases make costly business for the world.

For each of the thirty millions who annually die must be reckoned the expenses of sickness, doctors' bills, nurses' bills, other attendants' bills; what the individual might have earned while sick, had he been in good health; and funeral expenses.

For each of the thirty millions who are annually sick and recover must be reckoned expenses of his sickness, added to what he might have earned had he been well.

The diseases run from one day to many years—twenty, thirty, or more.

Three hundred dollars cost per individual of the sixty million victims is certainly a very low estimate. But at this rate the entire cost to the world is eighteen thousand million dollars per year.

Victory means that all the millions are not only not lost to the world every year, but that this whole amount of money by the year is transformed into better living for the sixty millions—better housing, better clothing, better feeding, better education.

The higher good to the world, year by year, along this line, is beyond estimate.

CHAPTER C

LONGER LIFE REWARD

TAKING the average duration of life as forty years, it follows that the entire population of the earth, 1,500,000,000,—one billion five hundred million,—dies, on the average, once in every forty years. This means that 37,500,000 die every year.

Allowing that 7,500,000 deaths are caused every year by accident, old age and disease not caused by germs, the other 30,000,000 must be caused by purely contagious and infectious diseases. One-half of these deaths,—15,000,000,—are children under six years. The other half,—15,000,000,—are youths, and adults mostly before middle age.

Therefore, with all the contagious and infectious diseases removed from the world, the whole thirty millions, who now die so early in life, would stand a good chance of living to an advanced age. This fact alone would materially lengthen the average duration of life.

In the second place, many parents are now weakened by the diseases; many more even have the diseases when they beget children. The diseases are not hereditary, but the tendencies to weakness are. Physically weak parents beget physically weak children. Thousands of children

are thus born into the world with physically weak constitutions. They start with a poor chance in the race of life, and die young.

But clean the world of all contagious and infectious diseases. What a change! As a rule, all parents become more healthy and vigorous, and beget more healthy and vigorous children. The children naturally live much longer lives, and thus the average length of life is much prolonged.

In the next place, all people, men and women, being better endowed, would develop stronger bodily and mental powers, be capable of greater endurance, and naturally live longer lives.

All things considered, therefore, victory over our Invisible Foes means nothing less than doubling once and a half times the average length of life—from forty to one hundred years. Men at one hundred years are then in the very prime of life. At two hundred, they retain their physical and mental powers as well as the best do now at eighty. The “oldest resident” then means a person who looks back upon a life of two hundred twenty-five or two hundred and fifty years.

The value of this longer life is inconceivably great. How often the man at eighty to-day, in reviewing his life work, only wishes he could live over his life. How much better he could do. He sees his mistakes, and knows how he could correct them. How he could make better plans, pursue better methods, accomplish infinitely better results.

But, in that new time the man at one hundred,

reviewing his life, seeing how he could correct all his mistakes, and how, by better methods, he could accomplish so much better results, has the actual chance of living once again the first hundred in the second hundred years, and thus actually to realize his highest hopes and ambitions. With his rich experiences in the first hundred years, he can accomplish at least five times as much in the second hundred years.

Applying this rule to all mankind, what infinitely good results to the world!

CHAPTER CI

MENTAL REWARD

THIS, of course, is the crowning reward. Mind controls the world — the more perfect its development, the more perfect the control. In the longer life-period the higher development is sure. Beginning life with so much better physical and intellectual endowments, aided by improved environment, the man develops faster, acquires a wider range of knowledge, and becomes earlier and better equipped for life work. Correspondingly greater is the achievement. During the first hundred years he accomplishes many times the usual amount. During the second hundred he multiplies this amount indefinitely. The total excels that of to-day as the work of Manhood excels that of Childhood.

No Utopia this. It is Nature — the higher Evolution.

Mars is our object lesson. As revealed by the telescope, astronomers tell us of broad zones of ice and snow around the poles of that planet; also of a system of markings extending from the equator, north and south, to the polar zones of ice. The markings, it is claimed, indicate nothing less than a vast system of canals, projected each way from

the equator to the polar ice fields. By the rotation of Mars on its axis water from the polar seas is whirled into the channels, filling them full to the equator, and by cross engineering, watering the whole planet. The polar ice belts accumulate during the polar winters, melt during the polar summers, keeping the water supply permanent.

It is necessary. Mars is far advanced in Evolution. Its internal heat has become much less, its crust correspondingly thicker. The thicker crust has new pores and cavities. These are filled with water drawn in from the surface of the planet by the force of gravity. When this took place, water on its surface was becoming scarce, threatening, on a large scale, drouth and famine. Martian engineers came to the rescue,— projected the grand system of irrigation.

Hence, it is claimed, on Mars dwells a superior order of intelligent beings, having a grandeur of intellect unknown to Earth. Their great engineering proves it. Our engineering,— subways, tunnels under rivers and small mountains, and canals across narrow isthmuses,— compared with the great Martian enterprise, dwindle to the merest kindergarten.

Not that it is needful for a moment to suppose that the Martian man, at the beginning, was superior to the Earth man, but that he has simply climbed to a higher degree of Evolution. Subject to a similar environment, he was subject to a similar “struggle for existence.” There was a

time, therefore, when he was attacked on all sides by Invisible Foes. The inevitable contagious and infectious diseases followed. For long centuries millions of his race were doomed every year to a premature grave; while he knew not the cause.

Finally, the Germ Origin of Disease was discovered. All was then plain. Knowing the cause, the Martian man finds a way to remove it, and stops the effect. With the right vaccines, antitoxines, quarantine, cleanliness, sanitation, he makes war upon the Invisible Foes until the last fiend is driven from his doors.

Relieved of the terrible incubus which so long weighed them down and kept them back, the Martians entered upon a new era of Evolution. They were better born. They had better environment. They had almost perfect health. They grew stronger. They could endure more. They lived longer. They could accomplish more. They grew wiser. They grew richer. They built up a higher civilization. Finally, they became the superior beings that they now are.

But Earthites take not a back seat. They are coming. They'll get there. Their greatest enemy conquered, rid of their great drawback, they enter upon a new era of Evolution. Bodily ills gone, mental ills go.

Religious superstitions no longer becloud the mind. Theological absurdities no longer disturb mental digestion. War is no more. Friction between Labor and Capital is gone. The upper and

lower classes of society act and react upon each other, mutually helpful.

Great thinkers crystallize their thoughts on the printed page; the masses read, think, climb.

Great discoverers unlock the secrets of the Universe; the masses behold, know themselves better, and better know their relations to the Universe.

Great inventors harness the forces of Nature; the masses with those forces till the soil, run the car, sail the ship, wing the air, and hold wireless chit-chat around the round earth.

Great financiers amass colossal fortunes, only to pour them back into the channels of education, to educate the people.

At the centers of civilization great universities rise, and University Extension becomes omnipresent with the masses. The same courses of instruction given by learned professors at the great centers of learning, are given by no less learned professors in every community.

For this purpose churches are transformed into lecture halls,—one hall taking the place of several churches. The church thus becomes a university extension—a Sunday Educator. And Sunday becomes a day of light—a real Sun-day.

Under these auspices Earthites grow wiser, richer, greater—mental reward in its fullness. Earth is about fifty million miles, or one-third, nearer to the Sun than Mars; therefore it should be one-third more favorable to Earth Man. Earth is also seven times larger than Mars. It, therefore,

requires a seven times longer period for its Evolution. Man on Earth has the advantage of this longer period, and, in the fullness of his Evolution, should be seven times the bigger fellow.

When, therefore, Earth becomes so far advanced in Evolution as to require for irrigation a system of canals projected from the equator both ways to the polar ice fields, the engineering job will be seven times greater than that job on Mars. But Earthites, with their seven times more skillful engineers, will be equal to the situation.

The immense cold storages of water at the poles are thus used in the day of need to supply the wants of man and prolong his days on Earth.

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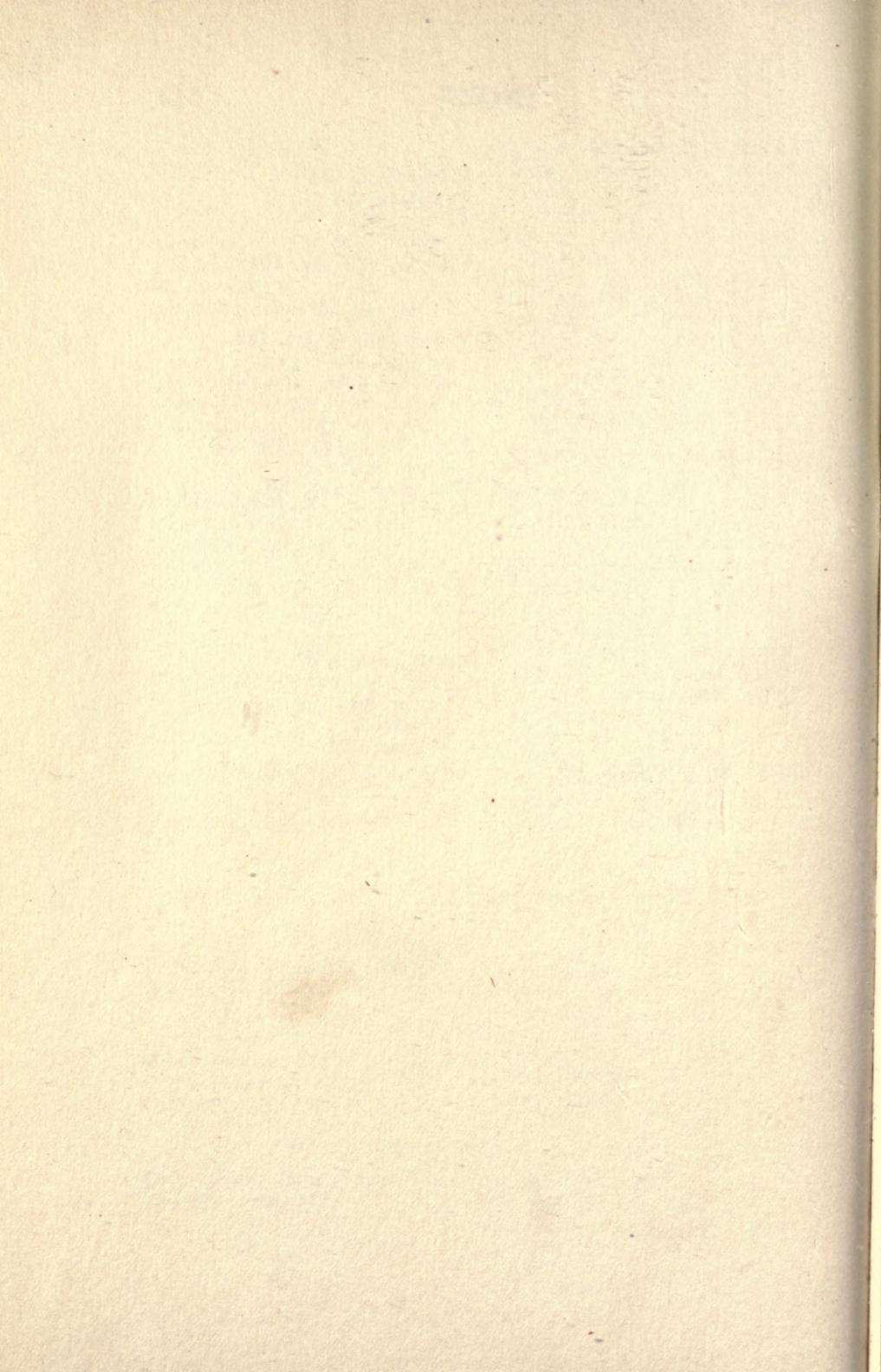
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